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TIMBER MANAGEMENT

A Programmatic Environmental Impact Statement

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PRELIMINARY DRAFT

PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

ON

TIMBER MANAGEMENT

PREPARED BY

BUREAU OF LAND MANAGEMENT

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K. Bergsvik

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C. History of Timber Management Program - H. Hess, K. Bergsvik

D. Forest Management Objectives and Policies - - - - - - - - - - - - - - - - - - H. Hess, K. Bergsvik

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G. Climate and Air - R. Schroeder

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INTRODUCTION

This environmental impact statement has been prepared pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969. It is a programmatic statement describing, evaluating, and discussing the environmental impacts of the timber management program conducted by the Bureau of Land Management on the forested lands under its administration.

Objectives

1. This programmatic statement will provide a basic and general description of the timber management program and a general evaluation of its environmental and human impacts.
2. It will serve as the foundation and framework for subsequent environmental analyses and statements which may be required for timber management actions on a regional, state or project basis. It will identify factors needing close attention in such analyses as well as areas needing further study for definitive information prior to taking action. Parts of the statement may also be extracted to serve as an environmental impact statement for a particular timber management action on an individual tract when judged to be applicable to the specific action and area.

Scope

The action described in this environmental impact statement includes all practices followed by the Bureau of Land Management for the purpose of producing raw material to help meet the nation's wood product

needs. As such, the action encompasses the reforestation, growth, protection, transportation and harvest practices associated with the production of a renewable resource. Certain of these practices, such as road construction or protection may be viewed as necessary regardless of actual forest land use, however, they are included and described in the context of the timber management program.

While the timber management program only represents one component of the Bureau's total forest management effort, this statement does not explicitly address itself to those programs or actions which are carried out for the purpose of producing or providing other forest values and uses on the public lands. Recreation, aesthetics, wildlife, watershed, range and other forest resource values are only described in terms of how they are impacted by the timber management program. Consequently, this report does not purport to represent a programmatic forest management impact statement when defined in a multi-resource program context. The statement is further limited to the ecological impact of the actions which originate or occur on the public lands. Thus, the environmental impact of the subsequent off-site processing of the raw material is outside the scope of this statement since this action is not within the purview of the Bureau's authority.

The final section of the statement that deals with alternatives to the action only addresses itself to the impact of the alternative of no timber management program or no action at all. While alternatives to

the timber management program could be viewed so as to include program levels, representing a range of timber production goals, the number would be infinite and it is felt that an arbitrary selection of one or two levels would serve no meaningful purpose. If the reader feels otherwise, the data set forth in this section can be extrapolated, to some degree, to whatever program level considered appropriate. However, this section analyzes the impacts of three possible options for replacing the amount of raw material that would no longer be made available from Bureau administered lands as a result of no timber management program.

Assumptions

Many of the practices associated with timber management are not currently being carried out on all of the forested lands under the Bureau's administration because of technical and economic constraints. However, the statement will not distinguish between the present program and potential future events. Rather, it is assumed that the possibility for the expanded or universal application of management practices does exist, and therefore, their impact on all forested lands is discussed. In addition, measures currently employed by the Bureau in planning and implementing the timber management program to mitigate the impact of the action on the environment will be totally ignored in the section of the statement dealing with unmitigated environmental impacts. Instead, the general objectives, policies and procedures followed in planning the timber management program shall be discussed in the earlier sections for

the sole purpose of placing the current program in its proper context. When appropriate, these and the on-the-ground mitigative measures currently taken in implementing the timber management program shall be brought out in the section dealing with mitigation. To do otherwise would result in a statement that used existing mitigative measures as its point of departure in describing environmental impacts. By following this approach it is hoped that the statement will be more applicable both now and in the future to the dynamics of change which characterize public land management.

I. Background of the Timber Management Program

In order to evaluate the Bureau of Land Management's timber management program it may be desirable to first provide the reader with some background information that bears on the action. Since history has played an important part in shaping the current program, certain of the major events relating to the public lands, the organizational structure, and the past development of the timber management program are briefly described in this section. In addition, current forest management objectives, policies and land use planning procedures that have evolved from legislation and other directives are presented in this section in order to place the timber management program, as described in Section II, in its proper perspective.

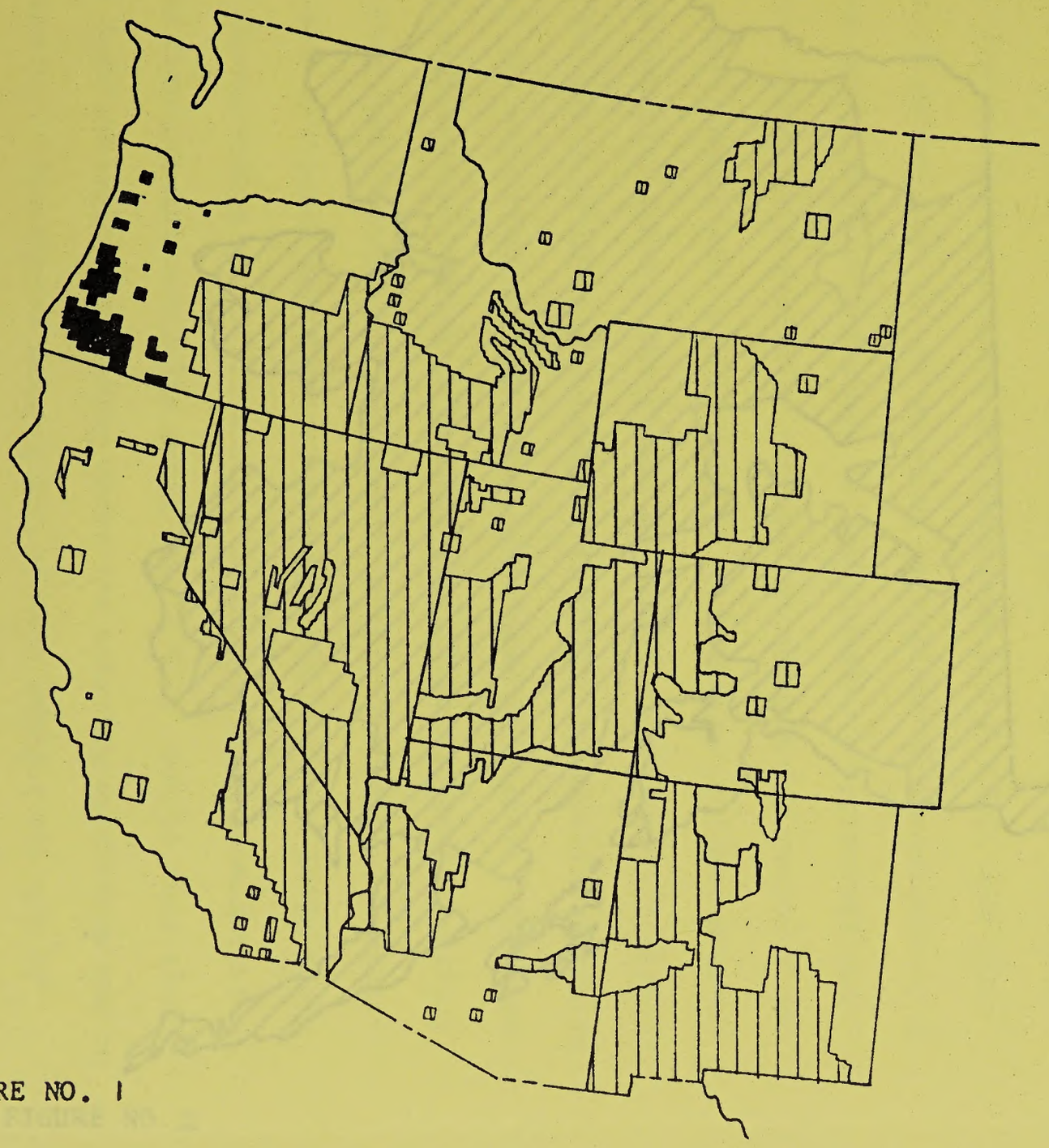
A. History of the Public Lands

The forest lands administered by the Bureau of Land Management fall into two principal categories. First, the public domain lands extending throughout the western United States, including Alaska and second, the western Oregon lands composed primarily of the revested Oregon and California Railroad Grant Lands and the Reconveyed Coos Bay Wagon Road Lands, which together are usually referred to as the O&C lands. Since their legislative histories vary, each will be discussed individually in this section, however, they are to be collectively considered as public lands throughout the remainder of this statement. (Fig. 1 & 2)

1. Public Domain Lands

During the 100 years after the United States became a nation it was presented with an unparalleled opportunity for development through

LAND ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT

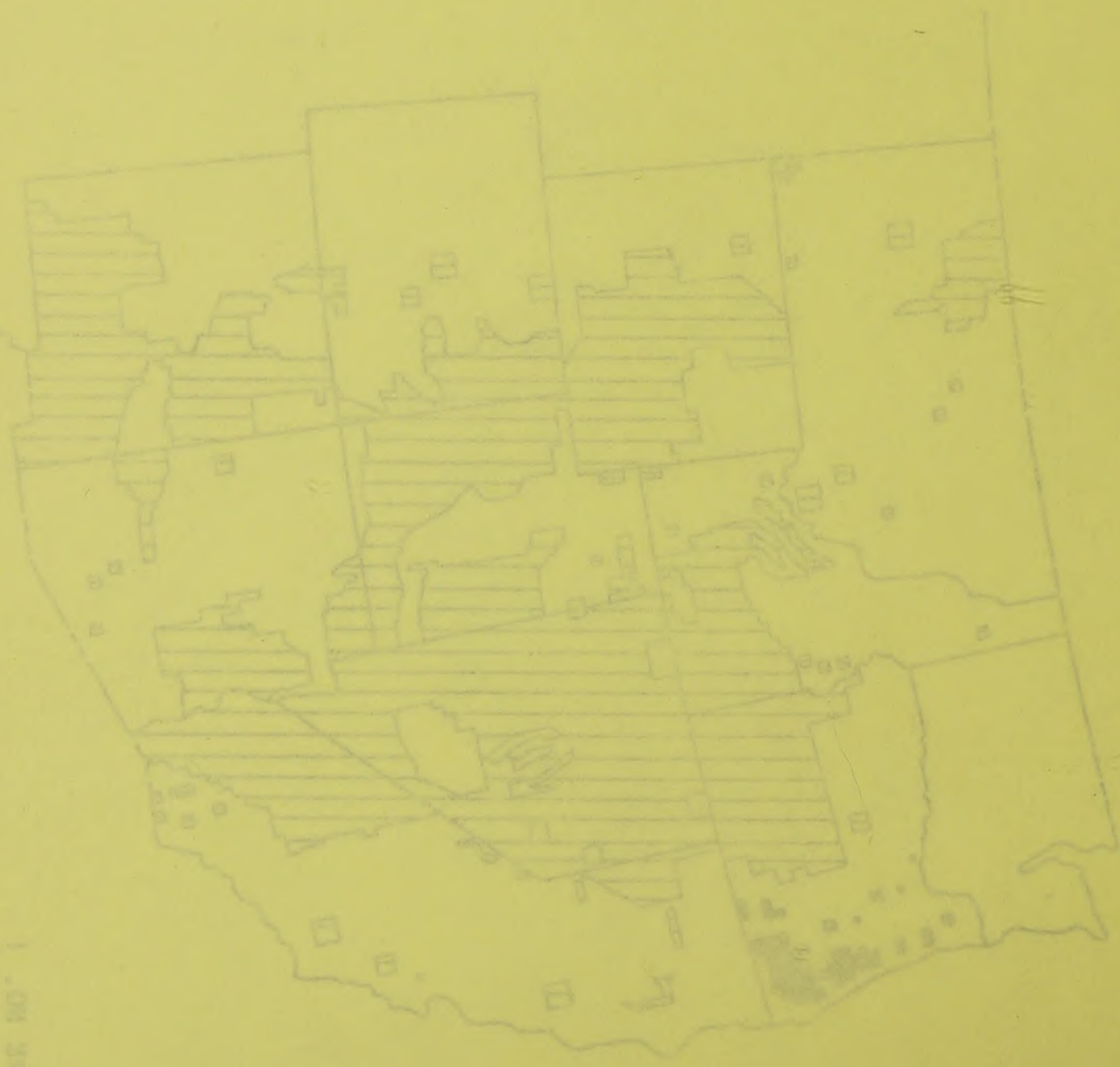


LEGEND

O&C Lands (BLM)

Public Domain Lands (BLM)

FIGURE NO. 1



ALASKAN LANDS ADMINISTERED BY THE BUREAU OF LANDSMANAGEMENT

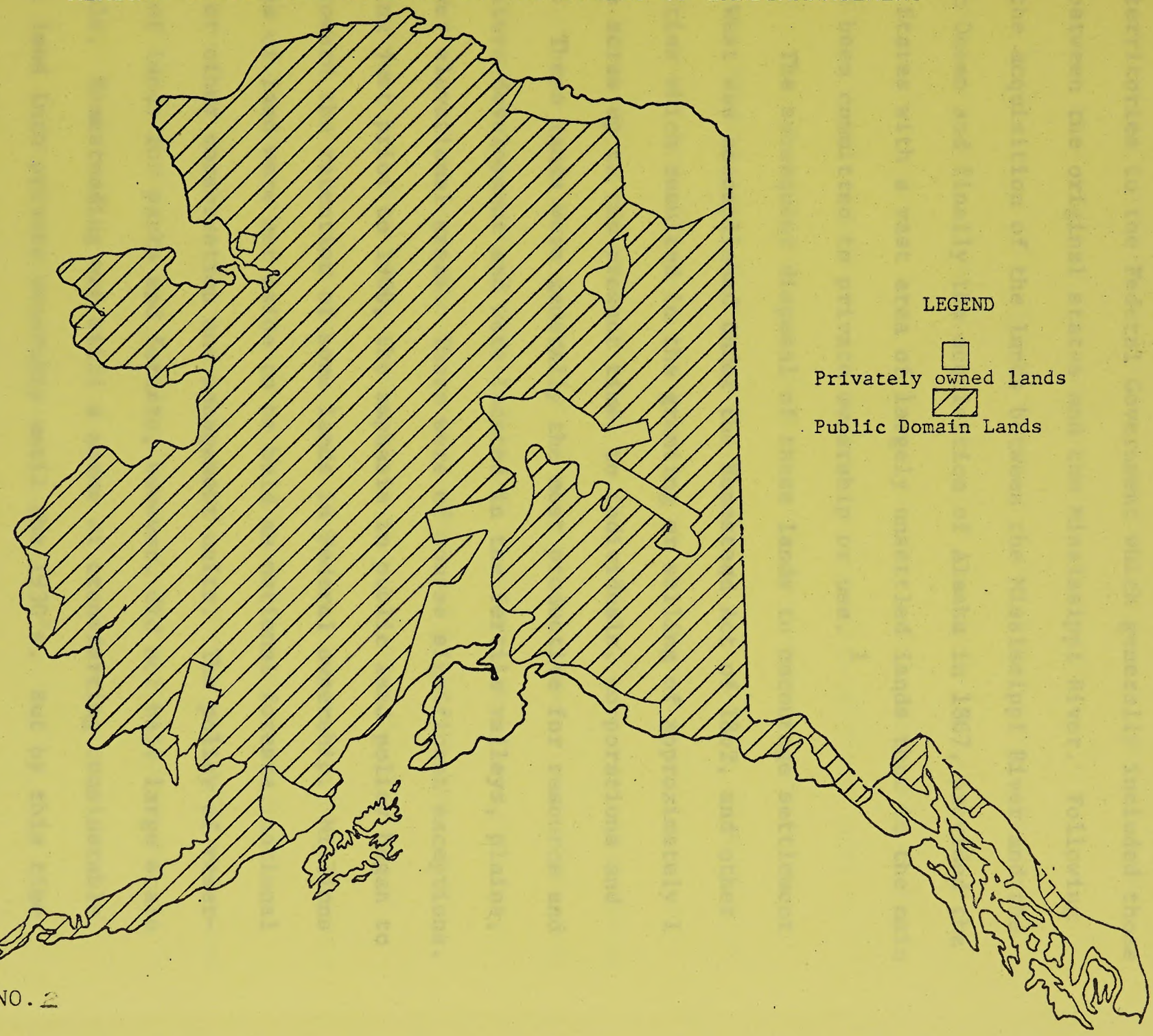


FIGURE NO. 2

the acquisition of lands. Seven of the original states ceded parts of their territories to the Federal Government which generally included those lands between the original states and the Mississippi River. Following this, the acquisition of the lands between the Mississippi River and the Pacific Ocean and finally the acquisition of Alaska in 1867, provided the United States with a vast area of largely unsettled lands that in the main had not been committed to private ownership or use. [1]

The subsequent disposal of these lands to encourage settlement of the West was accomplished under the Homestead Act of 1862, and other authorities which resulted in the granting or selling of approximately 1 billion acres up to the present time, to individuals, corporations and states. These lands were generally the most productive for resource and agriculture development and were located in the fertile valleys, plains, and lower elevational areas. There were of course significant exceptions. Beginning just prior to 1900, the emphasis in public land policy began to shift toward the retention of some lands in Federal ownership. Millions of acres of land were set aside to be held as national forests, national parks, or other conservation and management units. The policy of reservation of lands for parks and forests, however, did not halt large scale disposals. Homesteading was still a means of transferring considerable Federal land into private ownership until the 1930's. But by this time most of the land suitable for farming under the existing conditions was in private ownership. The Taylor Grazing Act of 1934 brought the era of

homesteading largely to an end. The lands that remained in the unappropriated and unreserved public domain, outside of those in Alaska, were mainly in the arid and semiarid grazing lands of the West. [2]

Today, the public domain lands in Federal ownership together with additional areas of acquired lands total nearly 755 million acres; one third of the nation's land surface. Of this total, about 210 million acres of the public domain have been reserved as national parks and national forests, under the administration of the National Park Service and Forest Service respectively, and approximately 75 million acres set aside for other specific uses. The Bureau of Land Management is responsible for the administration of the 470 million acres of the remaining public domain, representing over 60 percent of all Federal lands. [3] Approximately two-thirds of Bureau administered lands are in Alaska, a large portion of which are subject to disposal to satisfy state and native claims. Public domain forest lands under the jurisdiction of the Bureau total about 21 million acres, widely scattered, and are generally the residue left following the inclusion of the relatively higher valued forest lands in the National Forest system. The remaining public domain is primarily comprised of grasslands, desert, tundra, and woodlands scattered throughout the western United States.

2. Western Oregon Lands

The western Oregon lands are mostly the remainder of grants issued for approximately 4 million acres of public domain lands in the

latter part of the 19th Century to corporations for the purpose of providing incentives for the construction of railroads and wagon roads. The major grant was to the Oregon and California Railroad Company and included odd-numbered sections of public domain land in a strip 40 miles wide along a proposed railroad line extending from the Columbia River, near Portland, to the California line. Because some of the odd-numbered sections within this strip had already passed to state and private ownership, the company was given the right to select the odd-numbered sections in a strip 10 miles wide on each side of the original strip. Another railroad grant was made to the Oregon Central Railroad Company, later absorbed by the Oregon and California Railroad Company, for alternate sections in a 40-mile wide strip stretching from Portland to Astoria and McMinnville. A grant was also made to the State of Oregon for the construction of a wagon road from Coos Bay to Roseburg. This grant consisted of three alternate sections per mile in a strip extending three miles on either side of the proposed route and an additional indemnity grant extending three miles on either side of the initial place grant. The State transferred this grant to the Southern Oregon Company, its agent for construction of the road.

These three grants included a "settlers clause", as an accommodation to individual settlers, which set forth the terms which the grantees had to follow in disposing of any of the granted lands. In 1915, the Supreme Court held that the terms of the clause had been violated but

left to Congress the question of appropriate action. Congress responded by passing the 1916 O&C Revestment Act which returned 2,890,893 acres of the original railroad grants to the Federal Government. Three years later Congress passed a similar act returning 93,000 acres of the Coos Bay Wagon Road Grant.

Under these acts the revested acreage was to be classified as power site, timber, and agriculture with the proviso that any timber harvested be sold by competitive bid. Agricultural land, which included timber and power site land from which the timber was removed, was subject to homesteading. This was a continuation of the philosophy favoring agricultural development by means of public land disposal. Because of the high elevation, steep slopes and unsuitable soils for farming that characterize much of the revested lands, a negligible amount reverted to private ownership for homesteading purposes. The O&C Act of 1937 specified that all revested lands classified as timber land would be managed for permanent timber production, which in effect, stabilized the tenure of the lands so classified except for exchange purposes as subsequently authorized under the Act of July 31, 1939. Today, the O&C lands consist of approximately 2.2 million acres in a checkerboard pattern, the preponderance of which, represent the highest timber producing lands under the Bureau's administration.

B. History of Organizational Structure

The Constitution of the United States gave Congress authority to administer the public domain lands. However, Congress was forced to look

at the public domain as a source of revenues through land disposal actions since its financial resources were minimal and debts were high. In 1812 Congress established the General Land Office as part of the Treasury Department. The Land Office was authorized to survey, manage, and dispose of public domain lands primarily to encourage private settlement and development. Executive and administrative responsibilities were transferred from the Secretary of the Treasury to the Land Commissioner, with limited resource management authority. In 1849, the Department of the Interior was created. Originally called the Home Department, it was the sixth agency with cabinet status. The General Land Office, Office of Census, and Office of Indian Affairs were brought together in the new agency.

The passage of the Taylor Grazing Act in 1934 resulted in the creation of the Grazing Service within the Department of Interior, with administrative responsibility for the management of the public domain lands of the western United States. Shortly afterwards in 1938, the Oregon and California Revested Land Administration was organized as a division of the General Land Office with administrative responsibility for revested lands in western Oregon, generally referred to as the O&C lands. In 1946, the General Land Office and the Grazing Service were combined into a new agency called the Bureau of Land Management under the Department of Interior, with administrative jurisdiction for both the public domain and O&C. With the end of World War II there began a period of accelerating mobility of the American people and an increasing appreciation of the resource values of

the public lands. To cope with the new situation the Bureau started profound changes in its structure, personnel and approaches. Personnel programs emphasized professionalism.

Today, the Bureau has an organization of approximately 3,700 people, most of which are located in offices in the western United States representing a variety of professional and non-professional disciplines. Over 500 professional foresters in conjunction with wildlife biologists, fisheries biologists, recreation specialists, hydrologists, soils specialists, economists and related professional expertise are currently directly involved in the management of the forest lands under the Bureau's administration.

C. History of the Timber Management Program

In the early development of public lands, beginning the latter part of the 18th Century, no special consideration was given to the trees on the land, except for the reservation of small tracts of timber to be used for the construction of the Navy's sailing ships. Land was conveyed along with the timber to the settler, purchaser, or grantee, who often considered the forest as a nuisance to agricultural development rather than as a valuable natural resource. The forest lands remaining in public ownership were treated as a commons and trees were taken as needed for housing and fuel.

With the increasing pace of industrialization and the growth of urban communities in the East, the public forests became increasingly

attractive to large-scale commercial exploitation and settlement. The taking of timber in trespass became increasingly large-scale, along with the emphasis on the rapid disposal of the lands. As the extent of the devastation of the great American forests became widely recognized, the future of the forests became a subject of public controversy. Congressional response was the Forest Reservation Act of 1891 which eventually led to the establishment of the National Forests, under the administration of the Forest Service. Lands outside the National Forests and other reservations (such as the National Parks) remained largely unmanaged and unprotected. Generally, the situation remained unchanged until the mid-1930's when the President reserved all remaining public lands outside of Alaska (about 200,000,000 acres) for classification and in connection with the development of National land use policies. Specific authority with respect to timber, with the exception of the O&C lands, was generally limited to a few statutes authorizing free-use of timber and authority to sell "dead and down" timber. A principal timber activity of the General Land Office was policing of timber trespass. Because of the small staff available for the work, the activity was largely limited to trying to collect damages for timber trespasses which could be discovered and traced.

It was not until the early 1940's, with the advent of World War II, that a concerted effort was made to utilize the timber resource found on the public lands. This period generally marked the beginning of the formal timber management program that is described in its current state in subsequent sections.

D. Current Forest Management Objectives and Policies

The forest management program of the Bureau of Land Management is carried out in accordance with the laws, statutes, and regulations pertaining to the lands under its administration. The basic guidance set forth in these authorities requires that forest lands be managed under the principles of multiple use, sustained-yield and environmental quality. In this context, forest management is defined so as to include the management of the land along with the wildlife, water, minerals, timber, recreation, forage and other resource values associated with it. Consequently, in the hierarchy of objective and policy levels, these forest management principles take precedence over specific timber production oriented objectives and policies and, in turn, provide the framework within which the latter are developed. This point is raised only to explain to the reader why forest management and timber management objectives and policies are presented in different sections of this statement even though they are closely related and quite often difficult to differentiate between.

While the O&C Act of 1937 applies only to the revested lands in western Oregon, it typifies the intent of corrallary legislation in stating that forest lands, "shall be managed . . . for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating streamflow . . . and providing recreational facilities." This Act was the first law which provided specifically for multiple use and sustained yield management of Federal lands. It was later joined by the now expired Classification

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While the O&C Act of 1937 applies only to the revested lands in western Oregon, it typifies the intent of corollary legislation in stating that forest lands, "shall be managed . . . for the purpose of providing a permanent source of timber supply, protecting watersheds, regulating stream-flow . . . and providing recreational facilities." This Act was the first law which provided specifically for multiple use and sustained yield management of federal lands. It was later joined by the now expired Classification

and Multiple Use Act of 1964 which extended these principles to the remainder of the Bureau administered forest lands. The environmental considerations required under both of these Acts were made explicit and a procedural process for their evaluation set forth with the passage of the National Environmental Protection Act of 1969.

The three basic principles of multiple use, sustained-yield, and environmental quality are embodied in the following listing of the major objectives and policies that guide the Bureau's forest management program.

- That forest lands provide a balance of resource goods and services as determined by national goals and priorities in order to meet the economic and social needs of the public, both now and in the future.
- That land use conflicts, when they exist, be reconciled to the extent possible through appropriate management practices. If unreconcilable, that the land be classified for a single use or combination of uses in consideration of local, state, or national priorities.
- That lands be managed so as to achieve a high level or regular periodic output of the various resources without impairment of its productivity or quality.
- That lands be protected so as to minimize losses or damage to the forest resources as a result of fire, insects and disease.

- That lands be managed so as to encourage productive and enjoyable harmony between man and his environment, to promote efforts which will prevent or eliminate damage to the environment and stimulate the health and welfare of man.

The achievement of these objectives and policies requires the forest management program to be representative of a coordinated multi-resource plan that is based on technical, social, economic and environmental criteria. As such, its formulation and implementation involves the utilization of expertise relating to the biological, social and economic arts or sciences. Additionally, public input and review are solicited during the planning and subsequent stages in order for the Bureau to be more effective in responding to the public interest.

E. Current Forest Land Use Planning Procedures

A timber management program for a given forest is a product of a process known as the Bureau Planning System which is used to develop and maintain land use plans for all Bureau administered lands. * Under this system, land use plans are referred to as Management Framework Plans. The Management Framework Plan for a specific forest describes the various resource uses which are permissible in the area after consideration of the governing guidance, the facts about the resources and uses, the views of the public, and other inputs to the decision making process. In addition,

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* Refer to BLM Manuals 1601-1608 and A Draft of a Programmatic Environmental Statement on the Bureau Planning System, transmitted under IM 72-378 dated September 27, 1972, for further information regarding the system.

it describes the constraints on the planning for the realization of those uses which are necessary to insure compatibility of uses, protection and enhancement of the environment, stability of dependent communities, and other objectives of management. The plan is prepared by an interdisciplinary team at the field level, working in close coordination with a variety of groups and interests in an organized public participation process. Following the approval of the Management Framework Plan, program activity plans are then prepared for each resource action, such as the timber management program, to lay out, in detail, how each activity will achieve the objectives and meet the constraints shown in the Management Framework Plan. Consequently, the Bureau Planning System represents the process in which many of the mitigative measures described in Section V are brought to bear in shaping the timber management program.

The purposes of the Bureau Planning System are to:

- Permit informed and objective multiple use decisions through the identification and reconciliation of conflicting land and resource uses in advance of on-the-ground action (BLM Manual 1601.02A).
- Help insure that land and resource use, development and management plans and program decisions are responsive to Congressional, Departmental, and Bureau objectives (BLM Manual 1601.02B).

The Planning System has three classes of components for the development of land use plans: guidance, information and decision. Guidance includes basic Bureau responsibilities, land management objectives, principles

such as multiple use, sustained yield and environmental quality, planning assumptions, standards, program activity policies and outlooks and land use decision criteria, and guides. Information includes economic, environmental and social data, base map data, physical resource data, present resource use, trends and problems, and the capability and opportunities for future development of each resource. The decision component brings the guidance and information components together to develop the Management Framework Plan which represents a "general" plan designed to establish objectives and coordination for all of the resource program activities in the planning area. To attain this end the decision component consists of three steps. First, a proposal for each resource program activity is made based on its capability developed in the information component, the need for demand for the resource as shown by the economic and social data, public input, and the guidance relative to that activity as shown in the various Bureau guidance and policy statements. Secondly, the different resource activity recommendations are compared, overlaps and conflicts identified, potential "trade-offs" quantified, and the conflicts reconciled to the extent possible using land use criteria, environmental considerations and other guidance. Third, provision is made as a discreet step, for staff and public review and approval by the appropriate official(s).

While the objectives, policies, and procedures followed in the development of the timber management program are described in the next section of the statement, they are in actual practice, brought to bear

during the foregoing land use planning process. Consequently, the planning of the timber management program is to a large extent accomplished at the same time the Management Framework Plan is developed. Following the approval of the plan a more detailed timber management program in terms of scheduling, manpower, funds, etc., is developed for alternative production levels, when applicable, for those lands available for timber production.

Presently, the recently developed Bureau Planning System is being followed in updating the timber management and other resource programs for the lands under the Bureau's administration. With the exception of western Oregon, the public forest lands are currently undergoing a re-inventory in order to update the resource informational requirements for the formulation of the Management Framework Plan and the development of new program activity plans. The timber management program adopted in 1970 for the public forest lands in western Oregon preceded the Bureau Planning System, however, the procedures followed in that effort are consistent with the principles and intent of the Planning System. * These lands are currently undergoing an intensive inventory in order to increase and improve the quality of the resource data for application through the Bureau Planning System. These efforts are representative of the continuous land management planning cycle necessary in order to be responsive to technological progress, increased information, and changing public needs.

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* Refer to BLM Report, "An Allowable Cut Plan for Western Oregon," March 1970, for further information.

Bibliography

1 Public Law Review Commission Report, One Third of the Nation's Land, U.S. Govt. Printing Office, Wash., D.C., 1970, pg. 19.

2 Ibid., pg. 28.

3 Ibid., pg. 22.

Bibliography

II. Description of the Timber Management Program

The first part of this section will describe the physical extent and magnitude of the Bureau's timber management program on a national and regional basis. In the next part, the major objectives, policies and procedures that guide the planning of the program will be discussed. Finally, the operational aspects of the individual practices associated with timber production are described, along with some background information regarding their implementation.

A. Physical Extent and Magnitude

The Bureau of Land Management administers 23 million acres of commercial forest land or 4.5 percent of the total commercial forest land in the United States. These public lands support approximately 80 billion board feet (Scribner Log Rule) of merchantable timber which constitutes about 2% of the nation's wood supply. The production from Bureau administered lands in 1971 was 1.3 billion board feet, representing approximately 3 percent of the nation's total annual wood production, and was sold for slightly under $54 million. The production from Bureau administered lands is, for all intents and purposes, limited to 4 million acres of commercial forest land in the contiguous western states, since the remaining 19 million acres in interior Alaska are virtually non-productive because of their economic inaccessibility.

The western Oregon public lands consist of nearly 2 million acres or roughly 50 percent of the 4 million acres currently in the Bureau's timber production base and are some of the most highly productive lands in the nation. These lands produced over 1.2 billion board feet or almost 95 percent of the Bureau's total production in 1971 and nearly 20 percent of the total wood harvested in all of western Oregon. Consequently, the thrust of the Bureau's timber management program is currently localized to western Oregon. The remaining 2 million acres of public forest lands have not undergone an intensive timber management program, mainly due to funding levels. Management has been largely custodial and timber sales have been limited, averaging less than 100 million board feet annually.

The total Bureau production of 1.3 billion board feet in 1971 was made up of approximately 3000 individual timber sales, including advertised, negotiated, additional, and right-of-way sales having an average sale value of $41 per thousand board feet. Timber was offered for sale primarily through competitive bidding under relatively short term contracts. The predominant species sold was Douglas-fir followed by other major species such as western hemlock, ponderosa pine, sugar pine and western red cedar. Since over half of the commercial forests under the Bureau's administration are composed of overmature trees the preponderance of the volume sold consisted of old growth timber. Clear-cutting constituted the major cutting practices, in terms of the volume harvested, because of the preponderance of even-aged old growth Douglas-fir stands found in western Oregon. However, Bureau-wide, almost twice as much acreage was subjected to some form of partial cutting practice as compared to clearcutting. The salvage of 140 million board feet of dead material along with the commercial thinning of 26 million board feet of immature timber contributed to the total production. Wood products from public forest lands also included fuelwood, posts and poles, however, they totaled only 8 million board feet. Miscellaneous products, classified as nontimber, included Christmas trees, boughs, cones, ferns, etc.

In addition to timber harvesting, the following major practices associated with the timber management program were carried out in 1971:

- As part of the reforestation effort approximately 20,000 acres were planted with 8 million seedlings and 900 acres were seeded

with 850 pounds of seed. As a result of the ban placed on the use of Endrin as a seed protectant the seeding program has subsequently been drastically reduced.

- Approximately 9,000 acres were treated with herbicides in order to reduce competition to desirable tree species, either prepatory to reforestation or to release established stands, as a result of brush and hardwood encroachment. Chemicals used in the herbicide program have undergone some changes recently in light of the ban placed on such herbicides as 2,4,5-T.
- Approximately 750 acres were scarified prior to reforestation efforts.
- Approximately 6,300 acres of young unmerchantable stands were precommercially thinned.
- Approximately 500 miles of road were constructed over forest lands, most of which were built under the terms of timber sale contracts, the remainder with appropriated funds.
- The commercial forest lands were included in the 400 million acres of public lands protected from fire; of which 6 million acres were protected through contacts with other Federal, State or private agencies and the remainder protected directly by the Bureau. Approximately 2,300 acres of commercial forest burned with a loss of $961,000 in timber and reproduction values.

While the foregoing statistics apply to 1971 they typify the Bureau's current timber management program.[1] Recent events, however,

indicate that changes may be expected in the future regarding its makeup in terms of the land base and the intensity of management. This was evidenced by the timber management program adopted in 1970 for western Oregon, which resulted in the exclusion of 49,000 acres of commercial forest from the productive land base and 154,000 acres classified for modified cutting practices in order to protect and provide for other forest values and uses. In addition, the program called for approximately 290,000 acres of the remaining 1.8 million acres to be subjected to intensive silvicultural practices during the next decade.[2] Projecting ahead, a shrinking production land base coupled to an increase in timber management practices on the lands available for full timber production may well represent the trend in future programs.

B. Timber Management Objectives, Policies and Procedures

The timber management program is developed within the framework of the land use or Management Framework Plan, consistent with the objectives and policies that were followed in the formulation of the Plan as well as the general guidance that flows from it as discussed in Section I, parts D and E.

The primary objective of the timber management program is to produce a high level of raw material from forest lands classified as available for timber production, subject to the principles of multiple-use, sustained yield and environmental quality. In addition to the laws setting forth these principles, the program is designed to support the Housing and Urban Development Act of 1968. This law specifies a substantial increase in the supply of raw material from all Federal forest lands to help meet housing goals. More recently this same goal was expressed in the President's June 19, 1970, statement, instructing the Secretary of the Interior to: "improve the level and quality of management of the forest land . . . to permit increased harvest of softwood timber . . . to meet our housing goals."

The amount of timber to be harvested represents one of the major quantifiable elements of the timber management program that can be directly correlated to production goals. Consequently, the policies that are followed in planning the level of production warrant mention.

The primary determinants of the level of production, commonly referred to as the allowable cut, can be expressed in oversimplified

terms as being the amount of land available for the commercial production of trees and the expected yields from these trees, now and in the future. These determinants are, in turn, a function of such variables as land use, the regulation of wood flow, and the intensity of the timber utilization and management program and the length of the planning horizon. The major policies that address themselves to these variables and are followed in planning the timber management program, in terms of the allowable cut, are briefly as follows:[3]

- The size of the area for which an allowable cut is determined should be such as to permit access to a sustained source of timber for each of its substantial markets or its clusters of communities within which conversion facilities are sufficiently varied to utilize the timber output.
- The allowable cut shall only include forest land judged to be suitable and available for sustained timber production. Forested lands managed for aesthetic, recreational, watershed or other uses, to the exclusion of timber cutting, shall not be included in the acreage base used in the determination of the allowable cut.
- The allowable cut shall reflect the effects of multiple use management on the lands classified as suitable and available for sustained timber production. Forested lands shall be included in the allowable cut base where aesthetic, recreational, watershed and other uses are compatible with limited timber production.

However, their yields shall be adjusted to reflect any modified management or cutting practices which reduce timber productivity.

- The allowable cut shall be based on the principles of sustained yield which requires planning for a high level and undiminishing flow of wood over time. While the actual harvest may vary from year to year, the principle shall be considered fulfilled if the average annual output for each ten year period promises to remain constant or increase from one decade to the next.
- The allowable cut level shall include the volume from all planned timber harvesting practices such as final harvest, mortality salvage and commercial thinning. Their individual outputs may vary from decade to decade, however, in total shall meet the sustained yield principle.
- The unit of measure used in the allowable cut shall provide an accurate measure of the end product objective, i.e., sawlogs, pulpwood, etc. Additionally, trends in efficiency in the utilization of trees harvested will be recognized in the allowable cut.
- The influence of present and future intensive management practices, e.g., precommercial and commercial thinnings, shall be reflected immediately in the allowable cut when included in the timber management program. However, before any practice is considered for inclusion it shall first be analyzed for environmental, technical and economic feasibility.
- Forecasts of present trends or future changes will be a part of allowable cut planning. The planning horizon should be flexible,

with short horizons in some cases and long horizons in others. Normally the second decade shall represent the period upon which future practices shall be based. While no major developments or innovations beyond this twenty-year period shall be assumed, the practices forecasted to be in effect by this time shall be considered as ongoing programs thereafter.

- Generally, the allowable cut will be recomputed every ten years to coincide with the normal ten-year inventory cycle. However, if the situation warrants, it may be recomputed at any time in order to reflect catastrophic losses, policy, procedural and land use changes, or other changes in the assumptions underlying the existing cut.

The implementation of these policies in arriving at an allowable cut is accomplished by use of a computerized forest model developed by the Bureau in 1969 for long-range planning. This model projects the forest lands classified as available for timber production into the future in order to measure the effects of alternative timber management program levels on the allowable cut.* Program levels may be defined as management intensities relative to the inclusion of such practices as genetics, brush and hardwood control, precommercial and commercial thinning and/or others. Consequently, the model permits alternative program levels to

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* Refer to BLM Manual 5240 for further information regarding Allowable Cut Planning.

be evaluated on the basis of their respective production levels and economic efficiencies and subsequently serves as a basis for programming manpower and funds for the alternative selected. The selection of the alternative is guided by the Management Framework Plan, as described in Section I, Part E, for the particular forest along with budgetary and manpower considerations. (Note: This model can also be used in the development of the Management Framework Plan during the forest land use planning phase, as described in the section cited above, in identifying general program potential and in quantifying "trade-offs" in timber production when forest lands are excluded from cutting or subjected to reduced yields in deference to other forest values and uses).

The selected alternative is subsequently translated into a short-range activity plan in terms of an annual program for a five year period. Money and manpower needs in conjunction with planned accomplishments, consistent with the assumptions underlying the selected alternative, are identified for budgetary purposes. In addition to data directly related to timber management practices the budget submission includes support services such as cadastral surveying, easement and right-of-way acquisition and engineering. The development of the timber management activity plan is coordinated with other resource activity plans, e.g., wildlife habitat and watershed, and in concert with one another represent the forest management program for the planning unit.

One of the major inputs in formulating and in later implementing the timber management program is the annual timber sale plan. In addition to manpower and funding needs this document sets forth general information for each proposed timber sale area in terms of its location, approximate volume to be harvested, cutting practices to be followed, method of logging, road construction and access requirements, special contractual provisions and other relevant data. The plan is developed in accordance with the general land use and timber management planning policies, as previously described, and the following major guidelines:[4]

- Roads and other facilities will be kept to the minimum, and where needed, will be located, designed and constructed, to the standards necessary for the total land use and resource values involved. Excavation will be limited to the practical essential amount needed to meet the necessary standards. Planning will provide for stabilization of soil exposed and for rehabilitation of other environmental damage during construction.
- Cutting systems will be used which best meet the management goals and related land use prescriptions, and assure prompt regeneration of the forest. Selection, shelterwood, clearcutting or their various modifications are available options. If clearcutting is determined to be the appropriate system, the cutting units should not exceed 40 acres in normal circumstances. More than 40 acres may be appropriate for salvage of an area already environmentally damaged by fire, insect or wind, or where larger cutting units

will minimize road construction and other actions which would result in greater adverse environmental impact on the total forest.

- Cutting areas should be so designed that they blend naturally with topography and landscape. The cutting area should minimize the effect on the total forest vista, with due regard for future harvesting impacts of road construction and other relevant factors.
- Slash and cull log disposal will be an integral part of sale planning. Burning in place should be the last resort. Preference in order of consideration is utilization, chipping, lop and scatter, burying, pile and burn, burn in place. Follow-on reforestation and intensive management requirements must be essential considerations in the selection.
- Assurance of regeneration by natural or artificial means must be an essential element of sale planning.

The timber sale plan is reviewed both internally and by the public prior to approval to insure that proper and full consideration is given to technical, economic, social and environmental criteria. Comparable plans are also developed and reviewed for the other timber management practices including reforestation, site and stand improvement, etc. Together, these plans constitute the proposed timber management program, which is then subjected to final Congressional review and approval prior to implementation.

C. Operational Practices

Individual practices are carried out on the ground, consistent with the approved timber management program, for the purpose of increasing the productivity of the timber resource and its availability for public use. These practices range from reforestation to the construction of roads for transporting the harvested timber crop. They include protection, site preparation, seeding, planting, site and stand improvement, intermediate and final harvests, and the development of transportation systems.

Before describing these practices it should be understood that many practices associated with timber production are not being presently applied to all forest lands under the Bureau's administration because of technological, economic, budgetary or environmental constraints. One example is the forests of interior Alaska which are not presently being subjected to almost any operational practice, including harvesting, primarily because of the economic nature of their isolation from existing utilization and market centers. As another example, certain feasible timber management practices are not being carried out, or if so at a minimal level, in other forests because of budgetary and manpower limitations. Finally, certain practices such as fertilization, are currently restricted to limited test areas in order to determine their possible impact on the environment before they are considered operational. This matter is only raised to inform the reader that many of the practices described herein as part of the action are not actually followed on any

or all of the lands under the Bureau's administration due to the reasons cited above and others. Nonetheless, their potential for application does exist and therefore they are discussed.

The practices that are included in the timber management program are subjected to detailed operational planning and layout. This requires on-the-ground activities conducted by Bureau personnel prior to the action being taken, such as delineating the area to be planted, marking the trees or stands to be harvested, staking the road location, etc., in conjunction with gathering information pertinent to the practice. The outgrowth of these activities is a detailed plan for a specific area and the action to be taken on it. Since most practices are carried out by private parties, a contract, usually awarded on a bid basis, becomes the instrument for executing the particular action. For example, a timber sale contract is awarded to the highest bidder for a given stand of timber designated for harvest. The stipulations contained in the contract set forth the standards and specifications to be followed by the contractor in carrying out the action in accordance with Departmental and Bureau regulations and policies. These stipulations specify the measures to be followed or taken in accomplishing the action and the manner in which it is to be performed in order to minimize or eliminate its impact on the environment. The contract is administered, through inspections by Bureau personnel to insure compliance to its intent and the terms contained therein. Consequently, the operational planning, contract preparation and administration phases, together with the land

use and program planning phases, represent the hierarchy of levels upon which the mitigative measures to be discussed in Section V are brought to bear in the timber management program. These procedural and administrative levels are common to all timber management practices, however, the practices will be described solely in terms of their physical or biological impacts without regard to the mitigative measures actually employed in their planning and implementation.

1. Development

Practices included in the development phase of the timber management program are primarily aimed at (1) re-establishing trees on forest land following harvest or natural catastrophies, and (2) insuring satisfactory or optimum growth of these forests.[5] Actions directly associated with timber harvest, such as cutting practices designed to provide regeneration through natural seeding, are discussed in part 3, Harvest, even though they bear upon the questions of re-establishment and growth. The individual practices listed below are in the general order in which they might be carried out on the ground; although several may be accomplished simultaneously. Furthermore, not all of these practices are carried out on a given area. Many of the practices represent alternative methods, the choice of which is dependent upon the conditions on the area.

a. Tree Improvement

Tree improvement programs are developed to optimize specific genetic characteristics such as growth rate, or resistance to

disease. Major efforts to date involve (1) development of fast growing Douglas-fir and ponderosa pine, and (2) development of sugar pine trees resistant to white pine blister rust. The program provides genetically improved tree seed or seedlings for use in reforestation activities.

Tree improvement programs require development of (1) centrally located "seed orchards" where genetically improved seed can be produced, and (2) "progeny test areas" where improved seedlings can be grown and measured. Development of these areas often requires harvest of timber on selected sites followed by cultivation to prepare the site for planting. Cultivation methods used may include one or more of the following described actions.

High values associated with seed orchards and progeny test areas often require control of insects and disease with insecticides and fungicides. Such pesticides may be applied using hand compression sprayers, gas bombs, injection or tractor drawn ground sprayers.

b. Scarification

Heavy machinery such as crawler tractors, equipped with toothed brush blades are used to uproot woody vegetation and to pile it for burning, decomposition or disposal by burying. This measure is taken to prepare the site for seeding or planting by exposing mineral soil, conserving soil moisture, providing sunlight, destroying habitat of seed or seedling eating animals and/or guarding against fire.

c. Mechanical Brush Cutting

Heavy, tractor-drawn "brush-cutters" are used to chop and crush woody vegetation and debris in place in order to prepare the site for seeding or planting.

d. Mechanical Trenching - Furrowing

Tractor-drawn implements are used to construct furrows, trenches or cleared spots in herbaceous vegetation prior to seeding or planting.

e. Area Burning

Generally involves movement of one or more relatively continuous lines of fire over several contiguous acres for the purpose of destroying woody vegetation and debris, such as logging slash. This treatment may also require pre-treatment with a chemical such as Picloran (Tordon 101) to dry woody vegetation prior to burning. The treatment may be for the purpose of preparing for reforestation, reducing potential fire hazards, and/or protecting existing stands by destroying material infected with insects or disease.

f. Spot Burning

Piles, or concentrations, of woody vegetation and debris (such as logging slash or slashings from pre-commercial thinning or pruning) are destroyed by burning for the same purposes listed above.

g. Burying

Logging slash or debris resulting from scarification treatments are buried in pits constructed by heavy equipment such as crawler tractors for the same purposes as broadcast burning.

h. Chipping

Logging or thinning slash is handled by chipping it and disposing of it on site or other suitable disposal areas. In some instances the chips are transported to a utilization facility for processing.

i. Hand Clearing and Cleaning

Hand tools (such as hoes, axes, and power saws) are used to clear individual planting or seeding spots of vegetation and debris, or to remove competing vegetation from existing trees.

j. Seeding

In field seeding operations, as opposed to seeding in nurseries, seed may be scattered by helicopter or by crews walking over the area and depositing seed in selected spots. Seed used in seeding operations is normally treated with chemicals to provide protection from seed eating rodents and birds. Protection may be obtained when seed eating rodents "learn" not to eat treated seed after having ingested sub-lethal amounts. Protection from birds may be obtained by changing seed color.

k. Planting

Tree planting is done by hand using tools such as hoes, maddocks, dibbles, power augers, or tractor-drawn machine where terrain is favorable. Trees used in planting are classified as "bare-root" or "containerized". Bare-root seedlings are removed from the ground in forest nurseries, packaged and transported to the forest to

be planted. Containerized seedlings, however, are grown in containers and are transported to the forest in the containers. Depending upon the specific type of container, the planter may either remove the seedling from the container prior to planting or plant the container itself.

Tree seedlings are commonly treated in the nursery with a chemical to repell animals that may otherwise feed upon them. Repellency may be secured by rendering the treated tree unpalatable; growth that occurs after planting is not protected. As with seeding, one or more of the following described treatments may be used in an attempt to insure that planted trees live and grow at satisfactory rates.

1. Chemical Weed Control

Chemicals such as atrazine, simazine, dicamba, and 2,4-D are applied to control herbaceous vegetation, or 2,4-D and silvex are applied to control woody vegetation. Treatment may be accomplished prior, or subsequent, to seeding or planting and the applications made by aerial or hand methods.

m. Baiting

Poisoned bait may be distributed, aerially or by hand, to kill seed or seedling eating animals such as mice, woodrats, rabbits, snowshoe hare or porcupines.

n. Fencing and Screening

Involves construction of fences or screens to protect seed or seedlings from animal damage; fencing generally involves protection of entire areas from domestic livestock or big game while screens

may be used to protect individual trees or cut spots from nearly all kinds of animals.

o. Mulching

Usually involves placement of paper or plastic mulch around individual trees to control competing herbaceous vegetation.

p. Snag Felling

Live or dead trees sometimes have to be felled if they are tall enough to interfere with low flying aircraft conducting herbicide applications. Dead trees (snags) are often felled to prevent their throwing sparks in the event of a fire.

q. Fertilization

This practice involves aerial distribution, usually by helicopter, of a fertilizer, primarily nitrogen in the form of urea prills. Application rate is generally between 150 and 300 lbs. of effective nitrogen per acre. Although effects of a single application of ferilizer on annual growth can usually be recorded over a 10-year period, there may be a marked reduction after approximately 5 years. Frequency of application thus ranges between 5 and 10 years depending on local conditions.

Fertilization involves the movement of tons of fertilizer from supplier's base (by rail boxcar or truck and trailer) to an intermediate point, and from the intermediate point (usually by dump truck) to the base of operation (airstrip or heliport). The operation may thus require construction or improvement of the forest road system to allow movement of

large vehicles near to the fertilization site. Heliports or airstrips may also have to be built.

r. Precommercial Thinning

Surplus trees in established stands of young, pre-merchantable timber are cut or poisoned so as to release selected trees from competition for light, moisture or nutrients, thereby concentrating growth potential of the stand on fewer trees of better quality. The primary objectives are to produce merchantable wood volume and financial returns earlier than the unthinned forest, and to produce more total wood for harvest.[6] Thinning of merchantable size stands, where trees removed are sold, is discussed in the section Intermediate Cuttings.

Precommercial thinning may involve the use of power saws, chemicals (silvicides such as cacodylic acid or MSMA), axes or other tools to cut or poison individual surplus trees. Surplus trees are usually chosen from those trees whose crowns make up the general level of the stand canopy. Trees taller than the general level of the stand may be cut or poisoned only if soil moisture is a critical factor for increased growth of remaining trees. Cut trees may be left standing or forced to the ground.

The above techniques may also be used to cut or poison rows, or strips, of trees on the basis of "predetermined spacing or pattern with little or no regard for their position in the crown canopy".[7] This method, termed mechanical thinning, is usually limited to very young, uniform stands. Mechanical thinning may also involve use of heavy

machinery, such as crawler tractors and tractor-drawn brush cutters, to crush strips of trees several feet wide leaving narrower strips of standing trees in between.

Precommercial thinning may also be done for the primary purpose of removing diseased trees in order to control an infection such as dwarf mistletoe.

s. Pruning

Limbs of trees are cut from selected trees for the purpose of improving the quality of wood produced (i.e., knot free) or to control disease (such as dwarf mistletoe).

2. Protection

The primary objective of the protection program is to eliminate or minimize losses to the timber resource and other forest resource values resulting from fire, insects and disease. Since the nature of these destructive agents and the practices employed in combating them vary, each will be discussed separately in the parts that follow.

a. Fire

Two basic approaches taken on the ground to protect the forest from fires or control their spread involve hazard reduction and suppression. Hazard reduction includes such preventive or pre-suppression practices as slash disposal through chipping or burning, salvage of dead material, fire line construction around cutting areas, road building, firebreaks, and snag felling. Because most of these practices have multi-objectives and are carried out in the course of the actions identified in this statement as Development, Harvest and Transportation they will be discussed under one of these actions and not under Protection. Consequently, this section will be limited to practices employed in the suppression or control of going fires.

The objective of fire suppression practices is to break the three principles of combustion, as illustrated by the fire triangle (fuel, oxygen and temperature), at the most vulnerable place by the means available. The application of these practices, often in combination with one another, can therefore be classified on the basis of the three sides of the triangle, as follows:

- Fuel. Reduction in fuel by making a break in fuel continuity, accomplished by physical removal (construction of a fire line), making fuels less available (felling snags) or by making them noninflammable through application of dirt, water, or chemicals.
- Oxygen. Burial of fuels in dirt, smothering with water, fog or chemical substances.

- Temperature. Reduction of temperature through application of dirt, water, or chemicals and partial removal or separation of fuels.

The application of water and chemical retardants in combatting forest fires is usually accomplished by means of helicopters and fixed-wing aircraft. Fire lines are constructed by hand tools and also by the use of heavy equipment such as bulldozers.

b. Insects

The objectives of forest-insect control practices are to prevent or suppress epidemic outbreaks of injurious insects and to prevent their spread. With defoliator-type insects, the object is to hold down the injury to as low a point as possible until natural factors suppress the epidemic. In bark beetle control the objective is to prevent or suppress the development of a large beetle population, at the same time giving every encouragement to the natural control agencies, so that the natural balance may be restored.[8]

Control practices can be classified as silvicultural, biological, chemical and physical; the choice of which is primarily dependent upon the species of insect to be controlled, the degree of infestation, and the conditions that characterize the infested area.

(1) Silvicultural Control

This method employs the use of silvicultural practices directed towards preventing the occurrence of insect outbreaks as opposed to actions taken following insect infestations. It consists of maintaining the forest in a healthy condition and regulating its growth so that food conditions are unfavorable for injurious insects. The quantity and quality of insect food are controlled by regulating the composition, density, vigor and age of the stands.[9] Practices include the salvage or burning of windfalls, slash, and other potential insect-breeding places and by cutting operations to remove the trees or stands most susceptible

to insect attack. Under certain conditions cutting and regeneration practices are employed in a manner so as to favor the creation of timber stands of mixed species since they are sometimes less susceptible to insect damage than the pure stands. The objectives and practices associated with silvicultural control are by their very nature an integral and normal part of the timber management program.

(2) Biological Control

This method involves the use of living organisms which are either collected in an area where they are abundant or propagated under confinement and then released from the air or ground in the infested area. These organisms can be classified as:

- Parasites -- usually the young life forms of certain wasp and fly families.
- Predators -- such as lacewing flies, certain beetles, birds and mammals.
- Virus diseases -- produced by many different micro-organisms, including bacteria and fungi.

While the use of biological control methods have had some spectacular results with agricultural crop pests, their application in combatting forest pests have not been outstandingly successful.[10]

(3) Chemical Control

This method involves the use of chemicals which kill the insect by suffocation or through entry via the body wall, digestive tract or respiratory system. Insecticides are classified as:

- Inorganic -- containing elements such as arsenic, fluorine, mercury, copper or zinc.
- Botanical -- such as rotenone, nicotine and pyrethrum.
- Synthetic Organic -- includes the chlorinated hydrocarbons such as methoxychlor.
- Mineral Organic -- includes kerosene, fuel oil and lubricating oil which along with water are often also used as carriers for the other insecticides.

These insecticides are applied to trees in a number of ways; the choice being dependent upon the insect involved, the insecticide used and its formulation and the equipment available. The most common method, particularly in combatting defoliating insects, is spraying or dusting from an aircraft since it can be applied rapidly to large forested areas inaccessible from the ground. Ground methods include hydraulic spraying equipment mounted on vehicles and hand-operated units, used when total coverage of the tree or log is necessary. Mist blowers, consisting of an engine-powered fan, can also be utilized as a mobile ground unit to disseminate insecticides. Another method, used primarily for bark beetles, involves the injection of chemicals into the sapstream of a tree which are then taken up through the trunk causing mortality to the beetles in the inner bark.

(4) Direct Physical Control

Mechanical and physical insect control methods usually aimed at beetle-type insects, include the use of the following methods:

- Burning -- involves the burning of infected unmarketable material in either tree, log, branch (following pruning) or bark (following peeling) form after the material is piled or decked. It may also involve the burning of standing trees.
- Solar-Radiation -- involves turning thin-barked trees or logs so as to fully expose each beetle infested side to full sunlight for several days.
- Logging -- involves the removal of marketable material to utilization centers and burning the residual infested material. With the exception of widespread infestations this method is usually carried out in the course of the "normal" timber management program.
- Trapping -- involves the use of light, insect attractants, girdled and/or felled trees to attract insects. Host material is then usually destroyed by burning.

c. Diseases

The objective of forest disease control practices is to eliminate or minimize the occurrence or spread of heart rot, root rot, foliage, stem rust and other tree diseases. Diseases may be caused by the nonliving environment, such as unfavorable soil or atmospheric conditions, or by viruses whose nature is not yet understood. The majority of diseases, however, are caused by the activities of living organisms, i.e., slime, molds, bacteria, fungi, algae, seed plants and animals, including insects. [11]

Disease control measures currently carried out in the forest are essentially limited to silvicultural or physical practices. While a chemical has been developed for treating stumps to prevent the spread of Fomes annosus (root and butt rot) the small amount of damage caused by this disease does not warrant its application. Chemicals are used, however, in nurseries and seed orchards for disease control and are discussed under the Forest Development phase of the timber management program. Biological control, like chemical control, has strong appeal to the imagination but current technology and/or experience offers little hope for application in the forest in the foreseeable future. Consequently, they are not pursued in this statement.

(1) Silvicultural Control

This method employs the use of silvicultural practices aimed at the prevention or minimization of future disease outbreaks as opposed to actions taken following infestations and include:

- Development of disease resistant trees such as rust resistant white pine and sugar pine.
- Development of mixed-species stands where feasible, particularly when diseases are host specific.
- Development of pure stands of naturally disease-resistant tree species where feasible.
- Avoiding damage to residual trees during logging operations.
- Maintaining stands in healthy and vigorous condition by regulating composition, density and age.

(2) Direct Physical Control

This method employs the use of physical or mechanical means to control existing disease infestations and to recover marketable material, when applicable. Direct control practices currently being used are almost completely limited to dwarf mistletoe control and are usually carried out by use of silvicultural practices. Dependent upon the degree of infestation, stand composition, tree size and other variables either of the two following general approaches may be taken:

- Complete removal of all trees on and immediately adjacent to the infested area by cutting, burning or poisoning. Marketable material to be utilized.
- Removal and/or pruning of infected trees through precommercial thinning, commercial thinning or other partial cutting operations. Consists largely of discriminating against infected trees or disease prone species in selecting trees to be cut in the course of standard silvicultural practices.

3. Harvest

Harvest is the final phase of the timber production cycle and the first phase of the utilization cycle which represents the conversion of standing trees into forms useful to the human economy and arts. The steps associated with these phases of the production or utilization cycles include the felling of marketable timber according to selected cutting practices, the movement of logs or trees from stump to loading points by use of logging systems, and their subsequent movement over transportation systems to manufacturing centers. Each of these three steps, which include final harvest, mortality salvage and commercial thinning operations, are closely related, however, they will be described separately in the parts that follow.

a. Cutting Practices

The selection of the appropriate cutting practice is basically a matter of silvicultural desirability, i.e., a certain practice, or combination of practices, is applied to a given timber stand in order to favor regeneration and/or promote growth. An exception is the emergency situation, in which trees killed or damaged by fire, insects, disease or weather are promptly removed by an unscheduled salvage cutting. Factors to be weighed in selecting the cutting practice include species composition; stand age, stocking and condition (as related to tree vigor and risk of mortality); site quality and regenerative capacity; fire and insect hazards which may be created by logging slash; topography; and anticipated effects of weather conditions on the residual stand. Consequently, because

of the diverse nature of conditions within a given forest a variety of cutting practices is followed. Once the cutting practice(s) is chosen, those trees designated for cutting and/or trees reserved from cutting are identified on the timber harvest area.

Cutting practices have been classified by different authorities in various ways; e.g., as silvicultural systems for obtaining natural reproduction by several means [12] and by nomenclature descriptive of the action taken.[13] A practical classification (for the purpose of this subsection) lists cutting practices in two major categories, intermediate cuttings and final harvest cuttings, as follows:

(1) Intermediate Cuttings

These are practices applied prior to the major or final harvest of a stand [14] with the qualification that trees designated for cutting have commercial value.

(a) Commercial Thinnings

Various types and intensities of cutting applied to immature stands for the purpose of redistributing growth on the uncut trees, to recover and use material that otherwise would be lost, and thus to obtain greater total yield of merchantable material. [15, 16] Dependent upon the age of the stand and other factors, commercial thinnings are conducted at prescribed intervals over the life of the stand.

(b) Sanitation - Salvage Cuttings

These are made to remove individual trees killed or injured by fire, insects, fungi, etc., and those trees likely

to die prior to the final harvest in order to prevent the spread of insects or disease, and to utilize merchantable material before it becomes worthless. [17] Trees cut may be immature or mature, but tree condition, not age, is the criterion for removal.

(c) Shelterwood Cuttings

Removal of mature timber from a stand in a series of cuttings which extend over a period of years. In theory the series is divided into three parts, [18] two of which are herein classified as intermediate cuttings and the third as the shelterwood removal which is described under the final harvest cuttings:

- Preparatory Cutting, which prepares the stand for regeneration by removal of dying and defective trees and trees of undesirable species, prepares the seed-bed and encourages seed production. [18]
- Seed Cutting, which further opens the stand prior to seeding, thus making available the light and heat that the expected seedlings will require. [18]

(2) Final Harvest Cuttings

In contrast to intermediate cuttings, which include immature trees, final harvest cuttings usually remove only trees which have reached maturity. [19]

(a) Clearcutting

Removal of the entire stand in one cut. [20]

This practice is commonly applied to even-aged stands, in which most of

the individual trees achieve maturity simultaneously. Species which constitute such stands, e.g., Douglas-fir, are more or less intolerant (light demanding), and are most effectively regenerated by clearcutting. However, need for salvage may require that uneven-aged stands be clearcut. Disease infection in timber stands often requires clearcutting to remove sources that would infect young trees in the new forest.

(b) Seed-tree Cutting

Removal of the mature timber in one cut, except for seed trees (reserved for stand regeneration) left singly or in small groups. [21] These seed trees may be subsequently cut when the area is reforested.

(c) Selection Cutting

Removal of mature timber, usually the oldest or largest trees, either as individual trees or in small groups at relatively short intervals, commonly 5 to 20 years, repeated indefinitely by means of which the continuous establishment of natural reproduction is encouraged and an uneven-aged stand is maintained. [22]

(d) Shelterwood Removal Cuttings

These represent the third and final phase in a series of shelterwood cuttings as previously described under intermediate cuttings. They remove the remainder of the mature stand which, after establishment of reproduction, retards the development of young trees. The final cutting is the last of the removal cuttings. [23]

b. Logging Systems

The movement of felled timber to the loading point (landing) is accomplished through the use of a single system or combination of logging systems best suited for the area to be harvested. The selection is based on criteria which include:

- The physical requirements and capabilities of the applicable logging systems.
- The most economical combination of yarding costs, road construction costs, and major transportation costs.
- Silvicultural systems and cutting practices to be employed, and the priority sequence of harvesting.
- Protection of the reserve timber stand and preservation of soil and water sources.
- The safety of the men engaged in all phases of the harvesting operation.

While outside the scope of logging systems, the cutting or falling of trees and bucking them into tree or log lengths requires some mention at this point. These operations are a prerequisite to their movement and constitute a major part of the logging operation. Trees are normally felled in a manner so as to minimize loss due to breakage as well as to minimize damage to the residual trees or adjacent stands. Beds are sometimes prepared to reduce breakage when very large trees are cut. In addition to topographical criteria, the system of logging to be

employed is a factor in the manner and direction in which the trees are felled. In both the falling and bucking operation the chain saw is the common tool although mechanized blades mounted on mobile equipment are coming into more use, particularly in dealing with relatively small trees on gentle terrain.

The many logging systems available can be grouped under ground or aerial systems and they will be discussed on that basis.

(1) Ground Systems

These systems can move logs only by dragging (skidding) them along the ground. These are often called "conventional" systems because they were the original logging system and continue to be more widely used than aerial logging systems. Following are brief descriptions of some ground systems used in logging operations.

(a) Horse Skidding

Horses are still used advantageously in some situations. On suitable terrain they are well adapted to skidding small logs such as those produced in commercial thinnings. Horses can be used on narrow skid trails with minimum damage to the residual stand. They are best suited to skidding small logs down slope on gradients under 40 percent, for maximum distances not exceeding 600 feet.

(b) Tractor Skidding

Logging tractors are of two general types, crawler and wheel. The former has a tank-like metal tread while the

latter are invariably mounted on rubber and are known as rubber-tired skidders. Both types are sometimes used with a mounted arch or to draw track-mounted arches or rubber-tired sulkies, devices which suspend one end of the log or logs.

Both types of tractor are used most effectively for downhill skidding on slopes under 35 percent, and for maximum distances less than 1500 feet. Uphill skidding for short distances is feasible on gentle slopes, particularly for the larger crawler tractors. Often tractors complement other systems. A combination sometimes used on sidehill settings is downhill tractor skidding of the upper part and uphill high-lead yarding of the lower part to the same roadside landing.

(c) <u>High-lead Yarding</u>

Despite the increasing application of newer, alternative equipment to logging situations once operable only by high-lead, it remains one of the most important of the moving-cable systems. There are sound reasons for its popularity since many forested areas are too steep, broken or rocky for tractors. On clayey soils tractor operations are frequently impossible during the long rainy season.

Rigged for use, the power source (yarder) is located at the landing near a vertical spar usually 80 to 120 feet tall. As a turn of logs is yarded by the mainline cable toward the landing, they are dragged full length along the ground unless a stump or other obstacle is encountered. Then the vertical component of force on the mainline lifts the front end of the log until it noses over or around the obstacle.

Consequently, the high-lead system operates most smoothly and efficiently when yarding uphill. Downhill yarding is feasible, but logs tend to "hang-up" on obstacles and dig into the ground. When all logs within reach of the mainline are at the landing it is moved laterally. The process is repeated in radial fashion, with the spar as a hub, until all desired logs in the setting have been moved to the landing.

The high-lead system is best adapted to yarding clearcut settings uphill, with maximum yarding distance of about 800 feet as optimum, although longer "reaches" are possible. With careful operation by a skilled crew, the system can also be used for logging such partial cuts as sanitation-salvage, shelterwood and selection cuttings.

(d) Mobile Yarder-Loader Operations [24, 25]

Various methods of yarding are employed in situations where neither high-lead nor tractor logging is practical. The mobile yarder-loader is particularly adapted to removing small total volumes of timber, to operating in stands of low volume per acre, or in small timber on steep terrain.

While there are several variations of mobile yarder-loaders, they have certain common characteristics:

- All are self-propelled, and can be driven from setting to setting (as opposed to most high-lead yarders).
- All are equipped with booms or spars which, when erected, provide lift for yarding and for loading trucks when lowered.
- Most have drum facilities which permit being used as high-lead systems.

Some of these machines can yard logs to a reach of 1000 feet. However, under optimum conditions, usual maximum yarding distance is about 500 feet. Since they operate on the high-lead principle, mobile yarder-loaders are most efficient when yarding uphill.

These machines are well-suited to logging commercial thinnings, and sanitation-salvage, shelterwood and selection cuttings. A rather unique attribute is their capability of operating directly from an existing road, thus eliminating the necessity of clearing and excavating landings. As each small setting below the road is cleared of logs, which are merely piled or "decked" along the road shoulder, the machine is quickly moved a short distance along the road to its next setting.

(e) Other Ground Systems

Jammers and self-loading trucks are sometimes used for yarding, principally in small logging operations.

- The jammer (usually a homemade machine) employs an erectile boom and an engine-powered drum, on which is wound a wire-rope cable used for both yarding and loading. While basically a machine for loading trucks, the jammer may be used for yarding logs for relatively short distances (usually not exceeding 300 feet). On slopes too steep for tractor operation, the jammer's limited yarding capability can be useful with a system of roads on contours spaced at slope distances of 600 feet or less.
- The self-loading truck is commonly equipped with a short horizontal boom with fairlead, and cable wound on a drum powered by take-off

from the truck engine, Under favorable conditions, such trucks can yard logs from locations within 100 feet of roadside.

Both jammers and self-loading trucks tend to perform poorly as yarding machines because of low line speeds. Consequently, they are rarely used as such in operations requiring high yarding production.

(2) Aerial Systems

These are capable of moving logs suspended above the ground from stump to landing. Suspension may be complete or partial, i.e., logs can be suspended free of the ground (known as "flying" the logs) or one end of the turn may drag. [26] The three major types of aerial systems currently operational are skylines, balloons and helicopters; these are discussed separately.

(a) Skyline Yarding

Skylines are moving-cable systems which yard or swing logs suspended between a tail-spar and a head spar. The basic principle of movement is via suspension from wire-rope cables. Modern skyline systems are mobile and have lateral yarding capability. The newer systems can be used for both uphill and downhill yarding. Some are readily convertible to conventional high-lead operation, a feature which increases their utility. Modern skyline systems are of three general types; standing or fixed skylines, slacklines, and running skylines:

- Standing (fixed) Skylines. The operating range of the larger fixed skyline equipment is very great; maximum yarding distances of 5000 feet are possible. This potential, properly utilized, can greatly

reduce the road density which would be necessary for logging a given area by conventional means. The larger standing skyline equipment is best adapted to logging larger clearcut settings of heavy timber volumes per acre, in rough topography where the expense of developing intensive road networks would be prohibitive.

Smaller fixed skyline equipment with yarding capability of 1500 to 2000 feet is available. These machines and rigging are less costly and more flexible than the large skyline-cranes. Properly used, they are adapted to some partial cuttings as well as clearcuttings. While they do not offer the road construction cost saving potential of the larger skylines, they do have an advantage in this respect over the high-lead and tractor systems.

- Slacklines ("live" skylines). Commonly operating on a reach of 1200 to 1600 feet or more, slacklines have capabilities and applications comparable to those of the smaller fixed skyline systems.

- Running Skylines. These are the most recently developed of the skyline systems. They are becoming widely used in the northwestern United States, and are replacing standing skylines and high-lead systems in some applications.[27] A past disadvantage of these systems has been a rather short span capability (reach) of about 1000 feet. However, yarders with reaches exceeding 2000 feet are now available.[28] The running skyline is particularly well-suited to yarding intermediate cuttings and harvest cuttings of a partial

nature, where damage to trees left standing must be minimized. Properly equipped and utilized, running skylines may yard clear-cuttings as effectively as the high-lead.

(b) Balloon Yarding

Despite rather wide publicity, balloon logging has had only limited use to date. The few American balloon logging operations conducted to date have probably been economically marginal. Applications in coastal British Columbia have been more successful.

Balloon systems, which lift logs completely off the ground, have yarded for distances exceeding 5000 feet, although 3000 feet might be considered optimum. [29] Balloon systems are more expensive to operate than skylines because of additional costs of the balloon, its accessories, and gas for inflation. [30] Other disadvantages are instability of the balloon in moderate to strong winds, adverse reactions of the balloon to temperature extremes, and gas leakage. The increased expense of balloon logging may be economically justified where terrain and limited road access preclude logging with other systems.

Presently, balloon yarding appears to be best adapted to clearcuttings because of the difficulty of controlling the balloon in side winds and resulting lateral movement of the butt rigging and its suspended turn of logs, which can damage reserved trees in a partial cut. [31] However, experience indicates that the balloon can be used successfully to remove the overstory of a two-storied stand.

(c) Helicopter Yarding

Helicopter logging applications are in the formative stages. The very high unit costs of yarding with helicopters are the primary factor now limiting the use of these machines. However, high performance helicopters capable of lifting maximum loads of 20,000 pounds are available for logging.

In a well-planned helicopter logging operation, the machine flies logs to a landing located at a lower elevation than the area being logged. The helicopter can yard uphill, but this significantly reduces its speed. One-way flight distances should range from 1300 to 8000 feet.[32] The logs are hooked to a tag line 100-200 feet in length which is suspended from the helicopter, which then climbs vertically to clear obstructions before moving toward the landing.

Areas to be partially or selectively logged can be yarded by helicopter in cases where the surrounding trees or residual stand are not too tall. The removal of overstory timber to release young trees may present good opportunities for helicopter logging.

c. Transportation Systems

The primary purpose of transportation in the context of timber management is to provide a medium for moving logs from the landing or loading site located in the cutting area to a market destination which may be a few miles to a 100 miles distant.[33] The major mediums currently in use are land transportation and water transportation. The former consists of hauling the logs over a road and/or railroad system while the latter

involves the utilization of water to transport the logs. Since rail transportation is not used in moving logs on Bureau timber sale areas, and does not appear to hold promise in the future, it will not be discussed.

Water transportation includes the floating, rafting, or barging of logs on such natural waterways as rivers and lakes. Currently this method of transportation is not used in moving logs from Bureau administered lands, with the exception of some isolated instances in interior Alaska. If the timber resource of interior Alaska is subjected to any significant commercial development in the future, the rivers may become the major means of log transport. However, because of the many uncertainties involved water transportation will not be discussed further in this statement. Related to this matter is the use of water to store logs somewhere enroute to a manufacturing facility. At the present time the Bureau is involved with only one log storage dump, located on the Smith River in western Oregon. Since an environmental impact analysis has been made of this operation entitled, "Operations of the Smith River Log Dump as Related to Water Quality and Aquatic Resources," October 1972, it will not be included in this statement.

The dominant transportation medium currently in use is the hauling of logs by trucks over roads constructed on the public lands. Because of the intermingled ownership pattern the development of the road system often requires cooperation with adjacent landowners to insure access to the local, state and federal highways that lead to the manufacturing centers.

While the Bureau roads serve other forest values and uses the cost of their construction and maintenance is usually carried by the timber resource and is provided for under the terms of the timber sale contract. Consequently, in these instances, the time of construction is scheduled in conjunction with the sale of a given tract of timber. Following the completion of road construction they can be used jointly for protection and other activities associated with the timber management program in addition to timber harvest activities.

The width of these roads vary with the type of use, topography and other variables, however, in general they range from 14 to 20 feet in usable width and 40 to 100 feet across the cleared area. Not all roads are part of the permanent road network, some are used for a given period of time and then abandoned.

The operational practices associated with the development of the transportation system are included under the construction and maintenance phases and will be discussed on that basis in the following subsections.

1. Construction

This phase includes all the practices followed from the initial entry of equipment on the road location site to its availability for log hauling. The construction phase involves the movement of a portion of the earth's surface from one location to another and in its new position, creation of a desired shape and physical condition which

will serve the purpose for which the road is built. While roads are of varying standards and specifications the practices set forth are characteristic of those constructed on Bureau administered lands.

Basic construction operations are clearing and grubbing, excavation, formation of embankments, finishing and addition of bases and surfacing courses, and structures. Any or all of these operations may be performed on a given road project at the same time and may overlap to a certain extent.

a. Clearing and Grubbing

Clearing refers to the removal of trees, brush, etc. from within the limits of the designated area along the road's location. Grubbing refers to the removal of roots, stumps and similar obstacles to a nominal depth below the existing ground area. Frequently, they comprise a single operation and include the removal of topsoil to a shallow depth. This practice is primarily performed by a bulldozer to fell trees and uproot stumps, however, it may also involve the use of explosives and other equipment.

b. Excavation [34, 35]

This practice refers to the removal of natural material from its resting place and transporting it to a different place through an earth moving operation. It normally constitutes the major part of the construction operation and, in addition to the road itself, is carried out in conjunction with the installation of such structures as culverts,

drainage pipes and bridges. Excavation may be classified by the type of material excavated, as follows:

- Topsoil excavation is removal and stripping of the exposed layer of the earth's surface.
- Earth (or common) excavation is removal of the layer of soil under the topsoil and on top of rock. Earth can be broken down for ease of handling by plowing and ripping and is usually moved easily by scrapers or other types of earth moving equipment.
- Rock excavation is the breaking down of a formation by systematic drilling and dynamite blasting, for ease of removal by rockhauling equipment.
- Muck excavation is removal of soil that contains an excessive amount of water. This material is usually unstable under loading, and undesirable as an embankment material.
- Unclassified excavation is done without regard to materials encountered and may be any combination of topsoil, earth, rock, and muck.

The equipment most widely used in excavating work is a wheel or track (crawler) type tractor with a steel blade that can be raised and lowered. Equipped in this manner a tractor can push material from place to place and shape the ground. Tractors can also be attached to scrapers for excavation and short hauls, however, trucks or self-propelled scrapers are usually used when earth is to be moved any distance.

c. Embankment

This practice represents the construction of roadway embankments, including preparation of the areas upon which they are to be placed; the construction of dikes within or adjacent to the roadway; the placing and compacting of approved material within roadway areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits, and other depressions within the roadway area. When available excavation material is not sufficient for the embankments, borrow material from outside must be brought in.

Embankments are constructed in layers; the thickness of which varies. Compaction of each layer is by steel rollers, rubber-wheel rollers, sheepsfoot rollers, etc. which may be self-propelled or towed by a tractor.

d. Finishing

This practice is performed primarily by a motor grader and includes such items as trimming and finishing of slopes and the fine grading operations required to bring the subgrade to the final desired elevation.

e. Bases and Surface Courses

This treatment consists of all or part of a flexible pavement which is usually made up of a wearing surface, bases and subgrade. The wearing surface is usually made up of a macadam, bituminous surface treatment or gravel surface and must withstand wear, abrasion and displacement from vehicles and prevent water from entering the base of the roadway.

The bases are usually constructed of gravel or crushed rock and are layers of very high stability and density. The subgrade is the natural earth surface. In the usual instance it is the compacted soil in a cut section or the upper layer of an embankment section. Stone for use in the bases and surface course is obtained from nearby quarries or crushing plants.

f. Structures

These consist primarily of bridges, culverts, cattle-guards, fences, retaining walls, guardrails and riprap. These structures may require excavation, embankment, concrete work, backfilling, or other construction operations.

2. Maintenance [36, 37, 38, 39]

This phase includes the necessary repairs to keep a road in a safe, serviceable condition for use by logging trucks and passenger cars. These repairs include blading road surfaces, replacing and patching road surfaces, cleaning and replacement of culverts, cleaning ditches, replacing traffic signs, repairing bridges, brush and snow removal, slide removal and repairing settlements and washouts. Many of these repairs are necessitated by sudden failures, damage by storms, gradual deterioration, and occasional obstructions.

a. Surface Maintenance

Dirt road maintenance is primarily blading and leveling and cleaning out of the side ditches and culverts.

Gravel roads which are untreated require a heavy blading of the surface and side ditches in early spring and late fall. Heavy rains may

cause bad rutting and require the addition of gravel and additional blading. Road mix and macadam surfaces require patching of holes, ruts and unraveled areas and renewal of the surface periodically by application of a seal coat.

b. Shoulder, Sideslope and Roadside Maintenance

This maintenance consists of erosion control, visibility protection and brush control. The erosion control is accomplished by seeding and mulching and other soil stabilization practices and the brush control is accomplished by cutting back (or chemically treating) weeds and brush which obscure visibility and interfere with drainage.

c. Drainage Maintenance

This is accomplished by removing debris from culverts, correcting erosion by use of rock backfill, repairing eroded ditches with rock material and riprapping areas eroded by stream action. This also includes repairs to bridges and small structures.

d. Safety Maintenance

This includes sanding icy sections, replacing signs and protective barriers in order to preserve safety features of the original construction, dust prevention by spreading oil or water, debris removal and some limited snow removal.

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III. Description of the Environment

A. Geographic Location

Due to the location of the lands under the Bureau's administration the timber management program is limited to the Coniferous Forest Biome, which generally extends from the western edge of the grasslands in the Great Plains to the Pacific Ocean, including the major part of Alaska. A biome may be defined as a major biotic community; that is, natural groups of organisms characterized by the occurrence of certain plants and animals which are dominant and influent. [1] International Biome Programs have been initiated to analyze basic ecosystems and among other goals to establish a scientific base for programs to maintain or improve environmental quality. [2] Sharp demarcation lines between biomes have not yet been developed. Therefore, to utilize the basic advantages of the biome approach, and to collect, analyze and recommend on the numerous effects of the timber management program, organizational biome boundaries will include both aquatic and terrestrial communities.

The Coniferous Forest Biome represents a diversity of environments, species compositions, soils, resource products and land uses under greatly varying climatic conditions. This Biome has been broken down into three sub-biomes in an attempt to delineate and further homogenize the many environmental variations within the coniferous forest.

These sub-biomes are as follows (see also Figure 3).

- Taiga Coniferous Forest. This forest spreads across interior Alaska with narrow fingers following waterways into the Arctic regions south of the Brooks Range.
- Montane Coniferous Forest. This forest generally extends eastward from the crest of the Cascade Mountains to the eastern foothills of the Rocky Mountains and southward from Canada to Mexico. At approximately 43°N latitude, it extends westward into southwestern Oregon to include all but the western slope of the Siskiyou Mountains. From the Siskiyous it extends southward encompassing the Klamath Mountains and east slopes of the Coast Range of California.
- Northwest Coastal Forest. Primarily a rain forest, it generally extends southward along the Pacific Coast from southern Alaska through western Washington and Oregon and eastward to the crest of the Cascade Mountains. At approximately 43°N latitude, it constricts to a much narrower band along the west slope of the southern Oregon and California Siskiyou and Coast Range Mountains.

For each component of the environment described in the parts that follow the various characteristics common to all three sub-biomes (the Coniferous Forest Biome) are discussed and also the characteristics unique to a particular sub-biome are described, when applicable.

CONIFEROUS FOREST BIOME

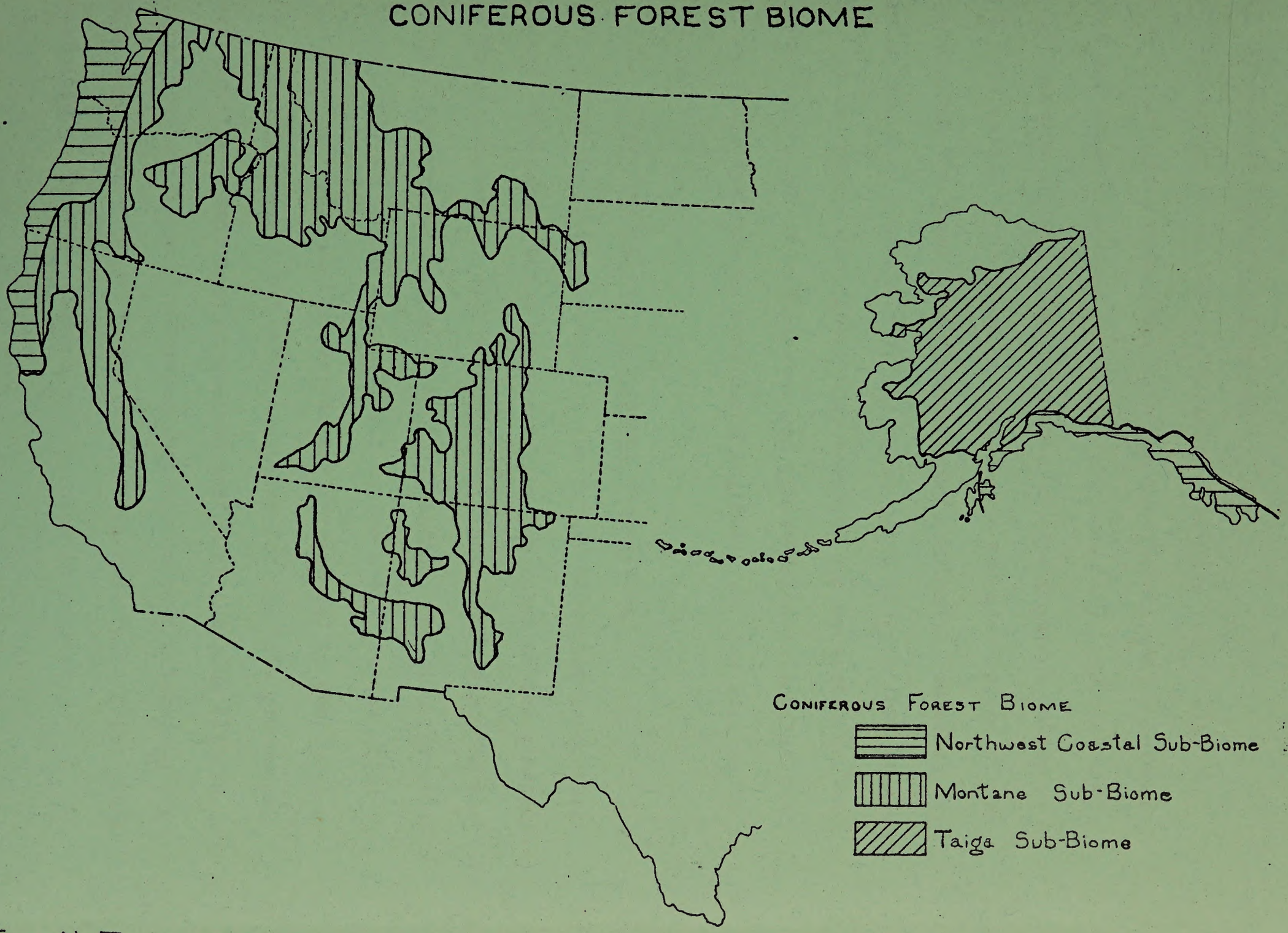


Figure No. 3

B. Ecological Interrelationships

A description of the ecosystem must concern itself with the forest as a biological community, with the interrelationships between the trees and other organisms comprising the community, and with the interrelationships between these organisms and the physical environment in which they exist. [1] In order to systematize the description of the forest ecosystem the physical environment and the biotic community will be briefly discussed separately in the first parts that follow. However, it should be understood that these components of the ecosystem are not independent but rather interdependent and interrelated influences that must in the final analysis be considered together, as they will be in the later parts.

1. General Physical Environment (non-living)

The inorganic aspects of the forest ecosystem constitute the physical environment which represents the sum total of the atmosphere, soil and water components, each of which contributes to sustaining the life of the biotic community. In the case of vegetation, the plant grows with its crown in the atmosphere and its roots in the soil. To the crown comes the warmth, light, carbon dioxide and oxygen; and to the roots come the mineral nutrients and water necessary for the life processes. Their availability depend upon an endless system of changing climate, day length, and soil development - changes that are in part related to the developing vegetation itself. [2] The physical factors that affect plant and animal life can be divided into broad groups as follows:

Note: Bibliography for Ecological Interrelationships is found on page 202

- Above the surface. These climatic factors include solar radiation, air temperature, air humidity, wind, lightning, and carbon dioxide content of the air. Precipitation, whether rain or snow, is not a major direct climatic factor as it affects the community primarily through its indirect effect on soil moisture.
- Below the surface. Geologic and soil factors include the nature of the parent material, the soil profile, physical and chemical soil properties and soil moisture relationships.
- On the surface. Includes the land forms and the standing or running water which provide nutrients and the immediate physical environment for aquatic plants and animals.

2. General Biotic Community (living)

The forest is made up of organisms, both plant and animal, mutually occupying a complex of environments which are dominated by trees and other woody vegetation. All of the organisms are in competition for the physical components of light, air, water, warmth and nutrients necessary for life. [3] Each in its turn creates part of the environment affecting the others. These organisms can be classified in terms of the basic functions they perform in the community:

- Producers. These are largely the green plants that assimilate the nutrient minerals by the use of considerable energy and combine them into living organic substance. They include flowering plants, gymnosperms, mosses, ferns, liverworts, multicellular green algae, red and brown algae.

- Consumers. These are chiefly animals that eat and digest organic matter, releasing considerable energy in the process. They include mammals, birds, reptiles, fish, insects, roundworms, flatworms, and parasitic fungi and bacteria.
- Reducers. These are chiefly bacteria and fungi that return complex organic compounds back to the original abiotic mineral condition, thereby releasing the remaining chemical energy. These include micro and macro-organisms such as millipedes, earthworms, mites, fungi and bacteria.

3. Coniferous Forest Biome Ecosystem

Combining the physical environment with the biotic community, the forest ecosystem becomes a complex of trees, shrubs, herbs, bacteria, fungi, protozoa, arthropods, other invertebrates of all sizes, sorts and description, vertebrates, oxygen, carbon dioxide, water, minerals, and dead organic matter that in their totality constitute the forest. [4] The ecosystem is constantly changing diurnaly, seasonally and over the long-term climatic cycles. Change is perpetual and goes on at a rapid or gradual rate depending upon the rate of changes in the climate, the soils, the land forms, the fire history and the biotic composition of the ecosystem. [5]

When the environment changes as a result of the actions of organisms so that there is an increase of fertility in the soil, decrease in light intensity, or some other modification, conditions may become more favorable for some other species than for those already present. There may then be a replacement of one species by another or of one community

by another, and this second community may be replaced by a third, and so on. Thus, a succession of easily recognized stages takes place in the development of a climax community. The final stage or climax tends to persist as long as there is no change in climate or as influenced by the actions of man. [6]

The interrelationships between and within the physical environment and the biotic community can be described in terms of the following integrated processes, each of which is vital to sustaining life in the forest, and in turn its value to the public.

a. Nutrient Cycle

Vegetation is the basic nutrient producer since, through the process of photosynthesis, it converts inorganic chemicals to a simple form of sugar known as glucose. Using water from the soil, carbon dioxide from the air, and sunlight, this process links nearly all living organisms with the sun; the earth's ultimate source of energy. A by-product of this process is oxygen. By means of further chemical changes, all of which take place in plants and some of which take place in animals, the basic sugar is converted into more complex carbohydrates, proteins, fats and other substances that support life. [7]

These nutrients, as well as others, continuously circulate through the ecosystem following fixed patterns or cycles and in the process are made available in various forms to animals. The plant eating animals constitute the first order of consumers, some of which are subsequently consumed by predator type animals or lived-off by parasitic type

animals, who in turn may be consumed by scavengers. When plant litter, averaging 3000 - 5000 pounds per acre annually, or plants and animals die and fall to the forest floor, the billions of decomposers convert their remains into inorganic substances. These include nitrogen, phosphorous, potassium and calcium which are the chemicals most often in short supply in the forest soil.[8] They are then, along with others, taken up by the plants through the root system, with the assistance of mycorrhizal forming fungi, thus beginning the cycle again, or stored in the soil. In the case of nitrates, if not looped back through the plants or stored in the soil, they are denitrified and the nitrogen returned to the atmosphere where it is available to nitrogen-fixing plants such as certain species of algae.

The forests are unique when compared to other biomes to the extent that a large amount of nutrients are stored in the trees for relatively long periods of time prior to being made available for recycling. Forest ecosystems cannot be patterned as typical food chains; trees are not usually palatable. Under natural conditions they are decomposed by micro-organisms or destroyed by fire. In managed forests, they are removed to a great extent from the system.

b. Energy Flow

The transmission of energy through the forest ecosystem is closely correlated to the nutrient cycle, however, unlike the process energy is not recycled. Virtually all energy enters the biotic community as sunlight, but only 1 percent of the light that falls on the

forest is transformed by green plants into the chemical energy of food. The remainder is reflected from the leaves, transmitted through them, or dissipated as heat.

The food that is manufactured by green plants is subsequently passed through the tissues of the plants, and the tissues of the plant-eaters, predators, scavengers, parasites, saprophytes and the other consuming and decomposing forms of animal life. In each group, some of the food is used to build tissue and some as fuel for bodily processes, growth, reproduction, and movement. The chemical energy of the food fuel is converted, through respiration, to heat energy that is lost to the air. Some energy is also lost in food eaten by foraging animals that do not live in the forest, by animals that leave when mature, by fires and by the removal of vegetation and game animals by man. [9]

Once energy is transformed from a stored form (in food or body tissue), to some active form (heat), it dissipates in the atmosphere and is lost to the biotic community. Life continues by virtue of the continuous influx of new energy as a result of solar radiation.

c. Hydrologic Cycle

Both the nutrient cycle and the energy flow are dependent in large measure upon the water cycle which controls the availability of nutrients to plant roots, their rate of movement through the plant, the conditions under which plant litter is decomposed, and the development of the soil profile which affects the availability of nutrients to the plant roots as recycling is initiated. [10] Thus, the

hydrologic cycle constitutes a vital part of the forest ecosystem in supporting vegetation, and in turn the entire biotic community.

The cycling of water in the ecosystem essentially consists of precipitation inputs from the atmosphere, runoff outputs in the form of streamflow, and a series of intermediate processes influencing the magnitude of the precipitation/runoff relationship. These include interception, infiltration and percolation through the soil, evapotranspiration, surface runoff and storage at various levels of the system. Consequently, the nature of the biotic community is both a function of the hydrologic cycle and, in turn, a major influence on it.

4. Ecological Variations

The foregoing physical and biotic components of the forest ecosystem and their basic interrelationships are common to the entire Coniferous Forest Biome. However, because of regional differences, primarily climatic, their make-up or nature varies between sub-biomes and warrants discussion.

- Taiga Coniferous Forest. Due to low temperatures and a short growing season the Taiga is the least productive in terms of the biomass of the biotic community. Despite long summer days, the annual growth rate of vegetation is low and regrowth when disturbed can be extremely slow. Because temperature exerts such a powerful limiting effect, only a relatively few kinds of organisms have become successfully adapted to the far northern conditions. Thus the entire living part of the ecosystem is built around relatively

few species. Basic relationships are simplified. The soil surface is characterized by a thick, spongy mat of living and undecayed vegetation (reduction by bacteria is very slow because of low temperatures), often saturated with water and dotted with ponds. [12] The soil depth is relatively shallow due in part to the underlying permafrost. Because of these, and other limiting factors, there is a low rate of nutrient turnover and energy flow. Ecosystems, like the Taiga, containing species of plants with low growth rates and animals with low reproduction rates are generally fragile in nature. [13]

- Northern Coastal Coniferous Forest. Due to favorable climatic conditions, the Northwest Coastal Forest is highly productive in terms of the biomass of the biotic community; particularly in the "standing crop" of producers. Unlike the drier sub-biomes, the precipitation/evaporation ratio is extremely favorable and the understory vegetation is well developed wherever any light filters through. Trees in conjunction with the abundant lower levels of vegetation combine to provide a thick layer of organic litter to be broken down by bacteria, weighing as much as 1500 pounds per acre, and other decomposers. The numbers of most biotic species and respective populations for the trophic levels, i.e., producers, consumers and decomposers, are relatively high resulting in a complex but productive ecosystem. Natural succession of plant life is rapid following surface disturbance.

- Montane Coniferous Forest. The Montane has a fairly high annual production rate despite the low temperatures that prevail over most of it during half the year. The soil contains a fair population of small organisms but comparatively few larger ones. Consequently, the rate of litter decay is slower in the Montane than in the Northwest Coastal Forest and in conjunction with other factors, is less productive in terms of biomass. The higher elevational zones, supporting alpine trees and meadows, have a short growing season and because of soil and related conditions are fragile in nature. Generally, the lack of moisture during the growing season represents the major limitation in the nutrient-energy-water components of the ecosystem.

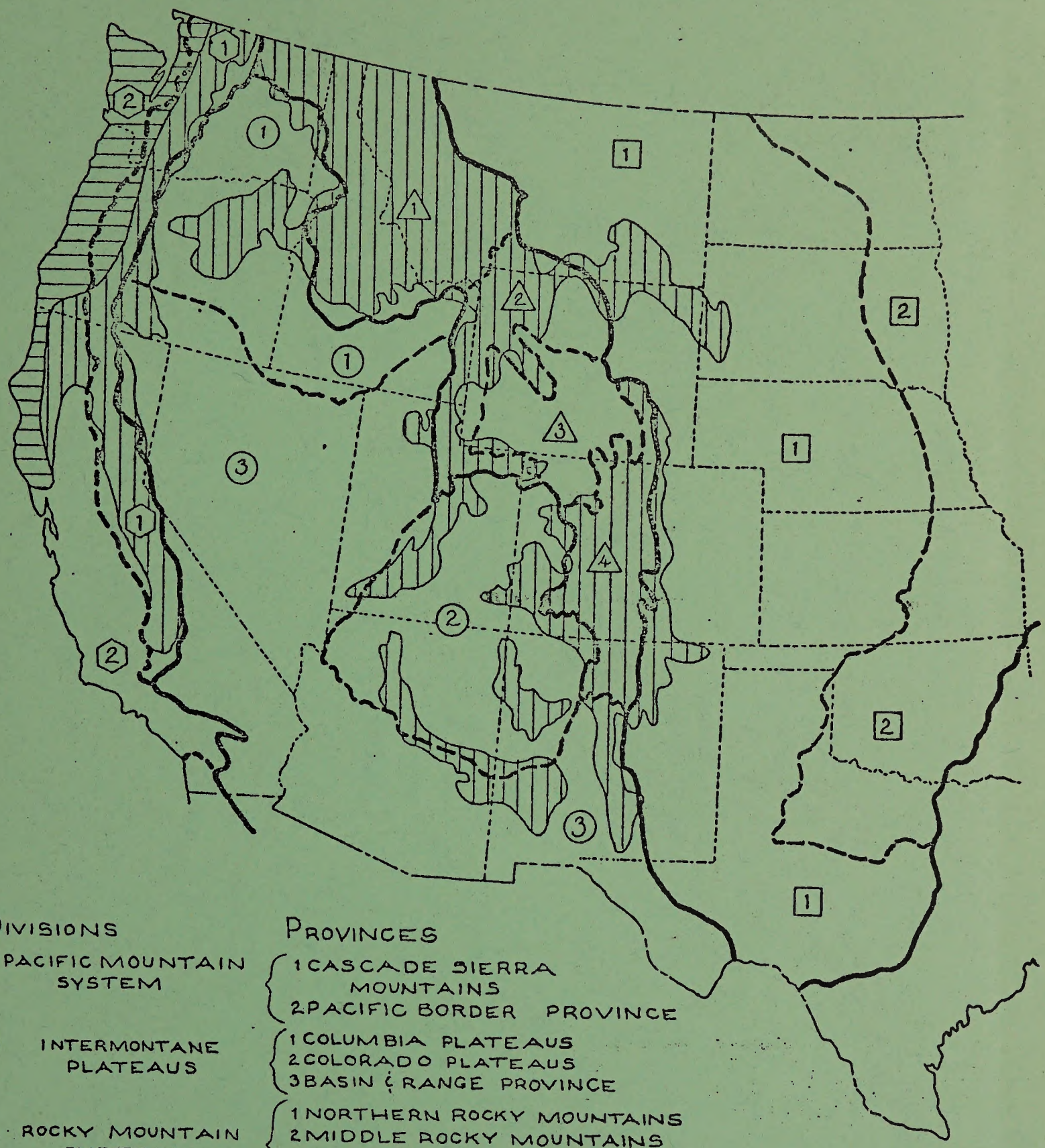
C. Physiography and Geology

A physiographic classification is based on those geologic processes acting on different rock types and rock structures which erode at different rates to form regions separated by recognizable boundaries. [4] The Coniferous Forest Biome of the Western United States and Alaska lies within four major physiographic divisions; (1) the Interior Plains, (2) the Rocky Mountain System, (3) the Intermontane Plateaus, and (4) the Pacific Mountain System. These major divisions are further subdivided into provinces. The Coniferous Forest Biome of the Western United States and Alaska covers portions of these provinces: [3] (Fig. 4 & 5)

Major Division	Province
Interior Plains	Great Plains Province
	Arctic Coastal Plain Province
Rocky Mountain System	Southern Rocky Mountains
	Middle Rocky Mountains
	Northern Rocky Mountains
	Arctic Mountains Province
Intermontane Plateaus	Columbia Plateaus
	Colorado Plateaus
	Northern Plateaus Province
	Western Alaska Province
Pacific Mountain System	Pacific Border Province
	Cascade Sierra Mountains
	Alaska-Aleutian Province
	Coastal Trough
	Pacific Border Ranges

Since these divisions and provinces may extend into several sub-biomes, the first portion of this section will describe the physiography and geology of the Coniferous Forest Biome that covers the Continental

PHYSICAL DIVISIONS OF THE UNITED STATES

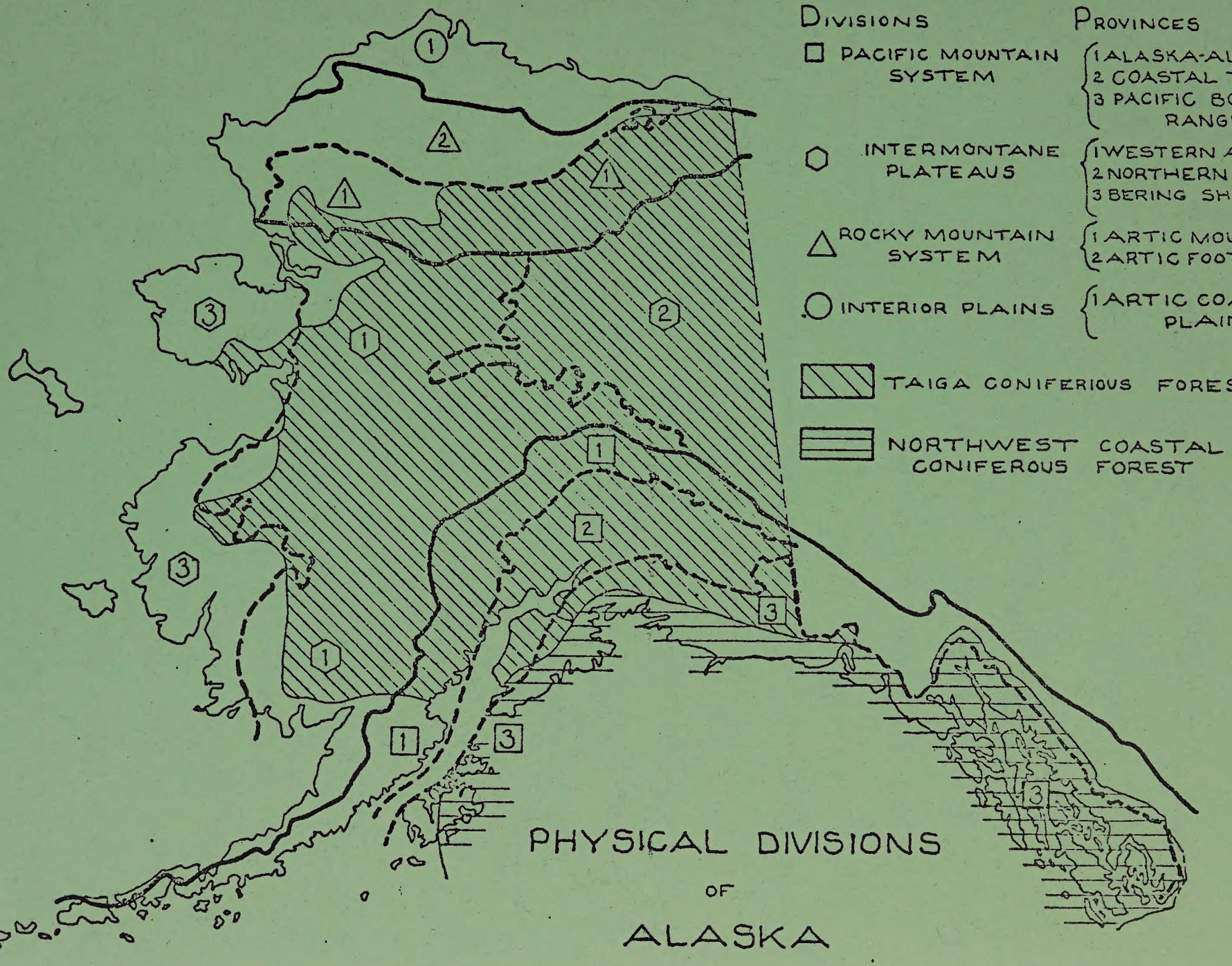


DIVISIONS	PROVINCES
⬡ PACIFIC MOUNTAIN SYSTEM	1 CASCADE SIERRA MOUNTAINS 2 PACIFIC BORDER PROVINCE
○ INTERMONTANE PLATEAUS	1 COLUMBIA PLATEAUS 2 COLORADO PLATEAUS 3 BASIN & RANGE PROVINCE
△ ROCKY MOUNTAIN SYSTEM	1 NORTHERN ROCKY MOUNTAINS 2 MIDDLE ROCKY MOUNTAINS 3 WYOMING BASIN 4 SOUTHERN ROCKY MOUNTAINS
□ INTERIOR PLAINS	1 GREAT PLAINS PROVINCE 2 CENTRAL LOWLANDS

NORTHWESTERN COASTAL CONIFEROUS FOREST

MONTANE CONIFEROUS FOREST

FIGURE No. 4



PHYSICAL DIVISIONS
OF
ALASKA

FIGURE No. 5

Western United States and the second part will describe the Coniferous Forest Biome covering Alaskan physiographic provinces.

1. Montane and Northwest Coastal Coniferous Forest (Excluding Alaska)

a. Interior Plains

(1) Great Plains Province - Physiography

Eastern portions of the Montane Coniferous Forest lie in the Great Plains Province. The western boundary at the foot of the mountains averages 5500 ft. with a range of 1000 ft. above and below that altitude. The eastern boundary lies between the 1500 and 2000 ft. contour. This indicates a fall in slope to the east of about 10 ft. to the mile. Erosion is more extensive along the margins, generally increasing towards the north. It is into this western portion along the Colorado Piedmont and Missouri Plateau that the Montane Coniferous Forest extends. The topography ranges from rolling hills in the southwest part, grading into mountains and glaciated terrain towards the northwest portions.

(2) Great Plains Province - Geology

The Great Plains Province lies within the central Stable Region, an area where major tectonic activity has been absent over much of geologic time. Rock types consist of a foundation of Pre-Cambrian crystalline rock, which is a continuation of the Canadian Shield, covered by a veneer of sedimentary rock. These sediments vary greatly in thickness from place to place, and several broad basins, arches and domes are present.[4] Unconformities in the sedimentary layers indicate that major transgressions and overlaps of prehistoric seas have occurred.

b. Rocky Mountains System

(1) Southern, Northern and Middle Rocky Mountain Provinces - Physiography

Much of the Montane Coniferous Forest covers the Rocky Mountain System. This great barrier of Mountains lies between the Interior Plains system on the east and the Intermontane Plateaus on the west.

The Northern Rocky Mountain Province differs from the Middle and Southern Rocky Mountain Provinces in landform appearance. The Northern Province lacks the orographic units, i.e., the mountainous topography which are easily distinguished in the Middle and Southern Provinces. The ranges in the Middle and Southern Provinces are linear features with the main crests on structural uplifts flanked by outward-dipping strata making hogback foothills. In the Northern Province most of the larger mountain masses are not linear and don't have an axial crest or monoclinal foothills. They are more like extensive plateaus deeply carved by erosion.

Relief in the Northern Province ranges from 2000 to 5000 ft. from the valley floors and mountain crests.

Relief in the Middle Rocky Mountain Province varies from 500 feet in some of the narrow erosion valleys to greater than 3000 feet at the summits of some of the lofty peaks.

Within the Southern Rocky Mountain Province relief ranges between 3000 and 5000 feet. This Southern Province has 46 mountains in Colorado which rise above 14,000 feet, and 300 more to 13,000 feet. Most rise from 500 to 2500 feet above the surrounding level. [5]

(2) Southern Rocky Mountain Province - Geology

The Southern Rocky Mountain province consists of broad, elevated, north-south strips of granitic type rocks generally flanked by steeply dipping sedimentaries. The sediments often make foothills and locally cap the mountains. In the southern part of the Province some of the mountains are made up of volcanic ejecta. Structurally these belts are large anticlines that have been deeply eroded.

(3) Middle Rocky Mountain Province - Geology

The Middle Province is separated from the Southern Province by the Wyoming basin. Rock types are similar to those found in the Southern Province. Most of the mountains have a granitic core flanked by sediments such as the Teton Range, which is a tilted fault block system. The Absoraka Range was formed by the accumulation of volcanics, mostly breccias. Much of the Yellowstone area is covered by lavas. Many of the mountains found within this Middle Province have been altered by glaciers.

(4) Northern Rocky Mountain Province - Geology

This Province is characterized by discordant, non linear mountain crests, mainly composed of igneous or metamorphic rocks, which are broken by occasional wide valleys with nearly flat or hilly floors filled with tertiary sediments. Within Idaho a great granitic batholith covering some twenty thousand square miles is exposed.

c. Intermontane Plateaus System

(1) Colorado Plateau Province - Physiography

The Colorado Plateau covers an area of approximately 130,000 square miles, characterized by badlands, high escarpments, deep gorges, and many strongly differentiated smaller plateaus.

The rocks exhibit a distinguishable pattern of horizontal bedding, dissected into hundreds of canyons, the largest of which is the Grand Canyon. Except for some of the canyon bottoms the plateau elevations lie between 5,000 and 11,000 feet, some of the plateaus being higher than the surrounding mountains. This Province generally overlooks its neighbors from a bold escarpment except to the north and east where it is bordered by high mountains.

(2) Colorado Plateau Province - Geology

The rock types making up the plateau are mostly thick bedded, horizontally layered, sedimentary rocks of Cretaceous to Tertiary age. Another significant type of structure in the Colorado Plateau Province is the laccolithic intrusion; a lens shaped intrusive body that has domed up the overlying sedimentary beds. [6] Several such intrusions have produced mountains on the plateau. The volcanic field is another important geologic feature that can be found on the Colorado Plateau, along the east, west and southern borders.

(3) Columbia Plateau Province - Physiography

The Columbia Plateau Province covers about 100,000 square miles in Washington, Oregon and Idaho. The topography consists of

flat, rolling hills, horizontally layered lava flows, all of which are broken by many variations such as the Blue Mountains, incised valleys, dissected plateaus and broad alluvial terraces. The Columbia and Snake Rivers have cut deep gorges in many places.

(4) Columbia Plateaus - Geology

Lava flows make up most of the rocks in this Province, occurring in horizontally layered flows from 10 to 200 feet thick. The Snake River cuts through more than 4000 feet of basalts along the Western boundary of Idaho. Granitic rocks underlie the basalts in Southwestern Idaho, being part of the Great Idaho batholith. Continental lakebed sediments occur in SE Oregon and SW Idaho. During the Pleistocene much of western Washington was altered by the effects of glaciation, leaving an area called "The channeled Scablands" covered with Pleistocene and recent sediments.

d. Pacific Mountains System

(1) Cascade Sierra Mountains Province and Pacific Border Province - Physiography

The Northwest Coastal Coniferous Forest boundary lies within the Pacific Border Physiographic Province. This Province is characterized by a chain of mountains called the "Coast Ranges" including the Olympics, Oregon Coast Ranges, Klamath and the California Ranges. East of the mountains is a line of valleys including the Cowlitz, upper Chehalis, and Puget Sound Valleys in Washington, and the Willamette Valley of Oregon, which is cut off in northern California and southern Oregon by

the Klamath Mountain Complex. Generally the northern part of the Pacific Border Province is expressed by peaks with similar elevations (accordant crests) and local alpine peaks; the central part by an uplifted peneplain (an eroded surface which has been uplifted by folding, faulting or intrusion) and the southern part by parallel ranges with rounded crests of subequal height.

The Cascade-Sierra Mountains Province which forms the eastern margin of the Pacific Mountain System constitutes a single Province but differs in character, between the north and south. The Montane Coniferous Forest boundary runs along the crest of the Cascade Range down to SW Oregon, then SW and down along the crest of the Coast Ranges.

It forms a single mountain barrier between the plateaus on the east and the valleys on the west. The length of the mountain range is more than a 1000 miles with an average width of 50 to 60 miles. Crest height varies but not over short distances. In the southern Sierras it ranges from 12,000 to 14,000 feet, with Mt. Whitney rising to 14,497 feet. The lowest average height is in the southern Cascade Mountains in northern California and southern Oregon. The province is narrowest at this place with high isolated mountains, and no continuous crests. From Mt. Whitney to northern California there is a gradual but not uniform decline in altitude. A 6000 to 8000 foot crest level is common farther north.

(2) Pacific Border Province - Geology

The geology of this province is diverse in character, varying from lowland troughs to broken coastal ranges.

The northern portion of this province is a partly submerged drainage system. Some of this area has been glaciated and is covered with glacial deposits overlying non-resistant geosynclinal sediments. A geosyncline is an elongated trough that will eventually form folded mountains. The coast ranges on this northern part are the result of an uplifted peneplain intruded by volcanics and partially carved by glaciers. Moving south the mountains grade from an uplifted peneplain on weaker Tertiary rocks, dissected, and with monadnocks (a mountain like mass such as a butte) of igneous rock rising above the adjacent topography. Farther south the mountains are composed of more complex, metamorphased rocks uplifted and dissected with longitudinal drainage patterns. The California Coastal Ranges are the southern most range of mountains covered by the Northwest Coastal Coniferous Forest. Their general trend is NW with elevations ranging between 2000 and 4000 feet. The ranges and valleys are roughly parallel with rounded crests and have been folded and faulted. Most of the rocks are metamorphased, including indurated sandstones, slate, and other resistant rocks.[7] Weaker sedimentary rocks occupy the structural troughs. Volcanic rocks are relatively absent from the area. Granite underlies much of the range.

The San Andreas Fault can be traced for 530 miles southeastward from Point Arenas at about latitude 39°.

(3) Cascade-Sierra Mountains - Geology

The Cascade Mountains geology is in contrast to that of the Sierra Mountains Complex.

The Cascades can be divided into the Northern Cascades and the Middle and Southern Cascades.

The Northern Cascades are covered with ancient sediments vastly older than the present topography, strongly folded and in part metamorphosed and intruded by granitic batholiths. Some granitic peaks such as Mt. Stuart occur irregularly as manodrocks. Glaciers have altered the topographic expression of many of the peaks.

Igneous-rock types in the Middle and Southern Cascades are mostly siliceous andesites. These congeal quickly after eruption to form a mountainous topography unlike the plateau basalts to the east which congealed slowly and flowed out to form plateau type landforms. Local accumulations of siliceous andesites were aided by eruption of fragmental products, bombs, lapilli, dust, and cinders and are in sufficient quantity to help determine topography.

The Sierra Nevada is a massive and continuous range extending from lat. 34°50' to lat. 40°20' a distance of about 400 miles. The massif is a tilted fault block, with a steep east-facing fault scarp. It has been submaturely dissected by deep valleys and the northern part has been glaciated. Three-fourths of the rocks are granitic in origin. North of lat. 37°20' about one-third of the rocks are sediments which have been metamorphosed and in part schistose. These beds have been closely folded. Farther north, Tertiary volcanics including lavas and tuffs were extruded near the crest of the range and flowed west in shallow valleys, displacing the streams. These rocks are in smaller proportions than those rocks making up the southern extent of the range.

2. Taiga and Northwest Coastal Coniferous Forests (Alaska)

a. Interior Plains

(1) Arctic Coastal Plain Province - Physiography

The Interior Plains System is the northern most physiographic division in Alaska. The Taiga covers the northeastern part of the Arctic Coastal Plain Province. The Plain is smooth, rising lowly from the Arctic Ocean to a maximum altitude of 600 feet at its southern margin. Drainage is poor and during the summer the surface is marchy. There are no glaciers but the entire area is underlain by permafrost at least 1000 feet thick. The base of the summer thaw zone is between ½ to 4 feet below the surface.

b. Rocky Mountain System

(1) Arctic Mountains Province - Physiography

This province is characterized by mountains, hills and lowlands, the highest peaks rising to elevations of 7000 - 8000 feet in the Brooks Range. Drainage patterns are diverse flowing north and south down the mountain slopes with the predominate drainage of the Brooks Range flowing south into the lowland areas. Glaciers have carved the rocks in the Brooks Range. Evidence of glaciation is expressed in sharp peaks and crested divides, cirques and a few tarns or glacial lakes. Small cirque glaciers are still present at the higher elevations in the central and eastern part of the range. Towards the west glaciers have carved the sedimentary rocks into cliff and bench slopes. The mountains to the west have rounded to sharp summits lower in elevation than the mountains to the east.

(2) Arctic Mountains Province - Geology

Most of the rocks making up the province are folded and over thrust Paleozoic and Mesozoic sedimentary rocks including limestone and shales and metamorphics including quartzites, slates and shcists. Granite intrusions occur in the southwest part of the Brooks Range.

c. Intermontane Plateaus System

Most of the Taiga Coniferous Forest of Alaska covers this physiographic division. This system has been divided into the Northern Plateaus Province and the Western Alaska Province.

(1) Northern Plateaus Province, Western Alaska Province - Physiography

This province consists of uplands and lowlands carved by glaciers. The topography ranges from low ridges having gentle slopes, narrow valleys of low country consisting of low-rounded ridges and open valleys, basins, marshy lake dotted flats, and highland areas consisting of even-topped rounded ridges rising 2000 - 4000 feet in altitude surmounted by isolated areas of more rugged mountains, some as high as 5500 feet. Moraine-dammed lakes can be found in some of the glaciated mountain passes, thaw lakes and oxbow lakes cover some of the lowland areas along the Yukon River. Much of this province is drained by tributaries of the Yukon River. Permafrost covers most of the province but where discontinuous permafrost occurs periglacial mass-wasting develops at higher altitudes and frozen muck covers the valley bottoms during the summer months.

(2) Northern Plateaus Province - Geology

Crystalline schist, granite, quartzite, slate, and mafic igneous rocks probably mostly Paleozoic in age, overly deformed Paleozoic and Mesozoic sedimentary rocks in the Northeastern corner of the province. Some of the mountains in the southeastern part are moderately folded and faulted sedimentary and volcanic rocks. Cliff forming rocks including formations of limestone, dolomite, quartzite and greenstones are also found in this area, along with continental sandstones and conglomerate of late Cretaceous and early Tertiary age. Farther west the basins are mantled with outwash gravel, silt and morainal deposits over Pre-cambrian schists and Mesozoic granitic intrusions.

(3) Western Alaska Province - Geology

Folded and faulted Cretaceous sedimentary rocks cover most of this province. Some of the gently rolling hills in the northwest corner are underlain by Paleozoic and Mesozoic metamorphosed volcanics and granitic intrusives. Lava flows mantled with river flood plain deposits and wind borne silt cover the lowlands towards the west.

d. Pacific Mountain System

(1) Alaska Aleutian Province, Coastal Trough and Pacific Border Ranges - Physiography

Three provinces make up the Pacific Mountain System. The Taiga Coniferous Forest boundary extends into the Alaska-Aleutian Province and the Coastal Trough Province. The Northwest Coastal Coniferous Forest is spread over the Pacific Border Ranges.

Many parallel rugged glaciated north and northeast trending ridges 7000 - 12,000 feet in altitude, and dotted with large lakes that occupy glaciated valleys make up the southwestern Alaska Ranges. Glaciated peaks varying in height between 6000 - 9000 feet cover the central and eastern portions of the Alaska-Aleutian Province. Braided glacial streams follow the trend of the glaciated valleys and major river drainages.

The Coastal Trough Province is a continuous belt of lowlands with uplifts of oval mountains breaking up the topographic expression. Glacial features, including drumlins, eskers, outwash plains, and moraines, are easily discernable in the lowlands. The mountains also show evidence of glaciation as is expressed by their rugged peaks and U-shaped valleys.

The Pacific Border Range Provinces which are covered by the Northwest Coastal Coniferous Forest includes a rugged barrier of mountains varying in altitude from 3000 feet in the western part to spectacular isolated blocklike mountains rising up to 19,000 feet in elevation. The central Gulf of Alaska has a more diversified topography marked by longitudinal beach and sand dune ridges, crossed by outwash plains and morainal topography.

(2) Aleutian Range - Geology

Granitic batholiths intrude into moderately metamorphosed and highly deformed Paleozoic and Mesozoic volcanic and sedimentary rocks in the southern Alaska Ranges. Structurally the rocks trend in a northerly direction.

The central and eastern Alaska Ranges is a complex synclinorium (a belt of folded inward dipping rocks) having cretaceous rocks in the center and Paleozoic and Pre-cambrian rocks on the flanks. [8] Granitic stocks and batholiths support some of the high mountains.

(3) Coastal Trough - Geology

Glacial moraine and outwash overlies poorly consolidated coal-bearing rocks of Tertiary age. The isolated mountains within the lowlands generally consist of metamorphic and granitic rocks of Mesozoic Age.

(4) Pacific Border Province - Geology

The higher mountain masses are composed of sedimentary and metamorphic rock, Mesozoic in age, underlain by crystalline schist and granitic intrusives. Volcanic and sedimentary rocks extend along the north side of the St. Elias Mountains. The general trend of the mountain masses is east-west.

D. Minerals [9, 10, 11]

The Coniferous Forest Biome of the Western United States and Alaska which include the Northwest Coastal Coniferous Forest and the Montane Coniferous Forest have a diverse accumulation of locatable, leasable and saleable minerals distributed within their boundaries. Although at a first glance it appears these minerals are randomly dispersed, a closer examination of an economic minerals map and geologic maps showing rock types, tectonics, and geo-physical anomalies, indicate there is some continuity in the occurrence of these minerals. Oil, gas, coal and geothermal steam are here included as minerals although they are not classified as such in the strict geologic definition of the term.

1. Montane Coniferous Forest and Northwest Coastal Coniferous Forest (Excluding Alaska)

Locatable mineral deposits are probably more pronounced in these sub-biomes than in any of the others. The deposits are principally of the vein type and closely associated with the Laramide orogeny of the Rocky Mountains, the Sierra Batholith and the Idaho Batholith within the Montane Coniferous Forest and the Pacific Coast disturbances within the Northwest Coastal Coniferous Forest. The deposits are distributed throughout the sub-biomes with the exception of few if any being found in Montane Coniferous Forests in east-central Arizona and west-central New Mexico, Wyoming and southeast Montana.

Locatable monerals that occur most commonly include gold, silver, copper, lead, zinc, iron, manganese, chromium, cobalt, nickel, molybdenum,

vanadium, tungsten, niobium, tantalum, tin, fluorspar, barite, gypsum, magnesite, and brucite.

Leasable minerals are principally evaporite bedded deposits found along the flanks of the mountain ranges, including potash, borates, sulfur and phosphate. Coal of all types, varying from anthracites through bituminous and lignites can be found with the principal concentrations occurring in the Rocky Mountain and western Interior Plains physiographic systems. Few if any leasable mineral deposits are found in these portions of the biome in northeastern Washington, northeastern Oregon, Idaho, northwestern Montana, and central Arizona although further exploration may yield minerals within these areas. Much of the lands have been classified as potentially valuable for geothermal steam and associated geothermal resources. It is unlikely that the other leasable and locatable mineral deposits will occur in areas of primary importance for oil and gas. (Fig. 6 & 7)

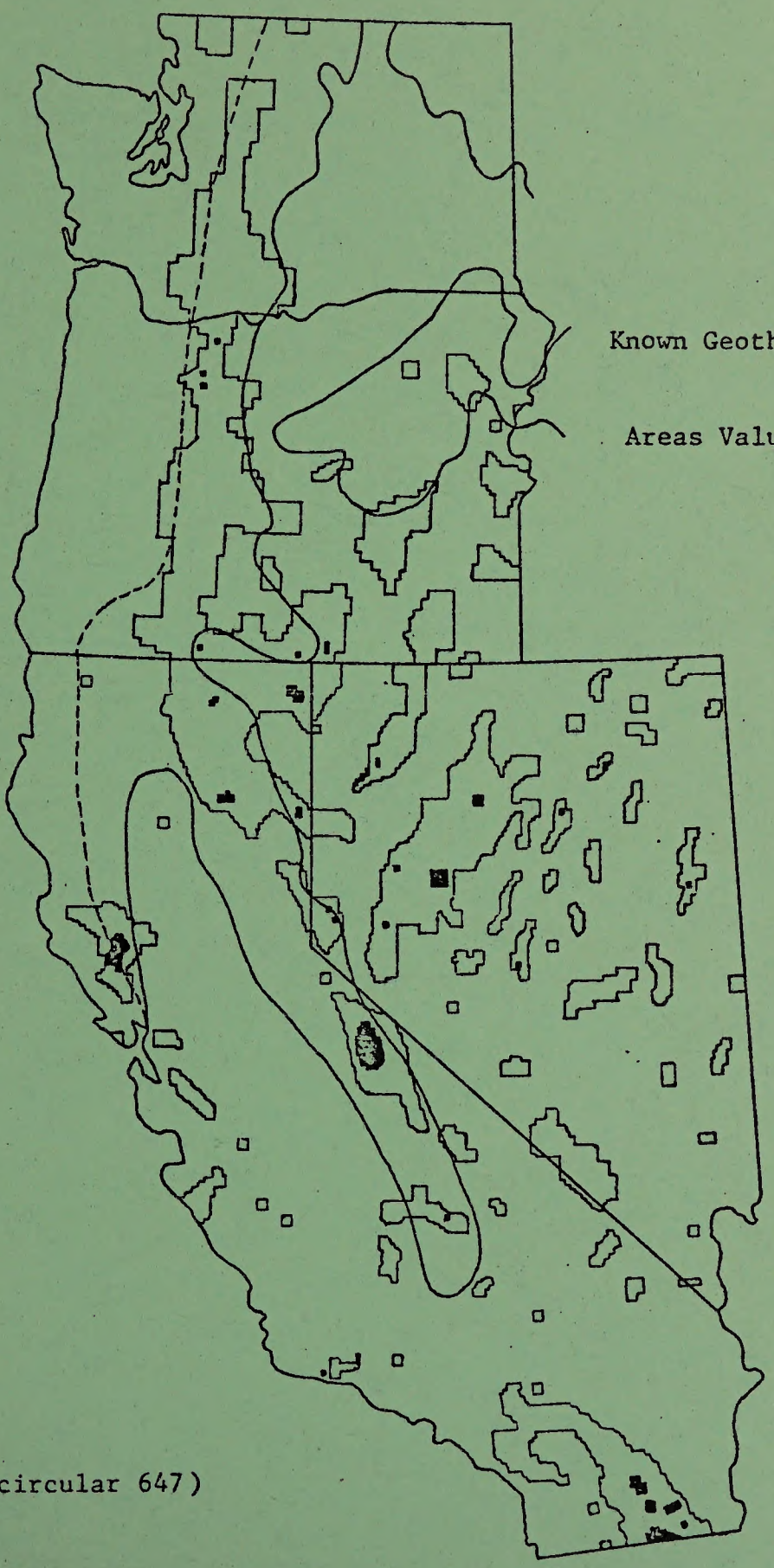
Salable minerals including sand, stone, gravel, pumice, pumicite, cinders, clay, other mineral materials and petrified wood are ubiquitous throughout the biome.

2. Taiga Coniferous Forest and Northwest Coastal Coniferous Forest (Alaska)

Locatable minerals are found throughout the Taiga and Northwest Coastal Coniferous Forest areas. (Fig. 8) The prominent minerals include fluorspar, barite, gypsum, zinc, gold, silver, copper, lead, tin, and platinum. The gypsum which is found in the northwest coastal area is of the evaporite type. Most of the minerals are found in close association

MAP OF THE WESTERN UNITED STATES SHOWING LANDS

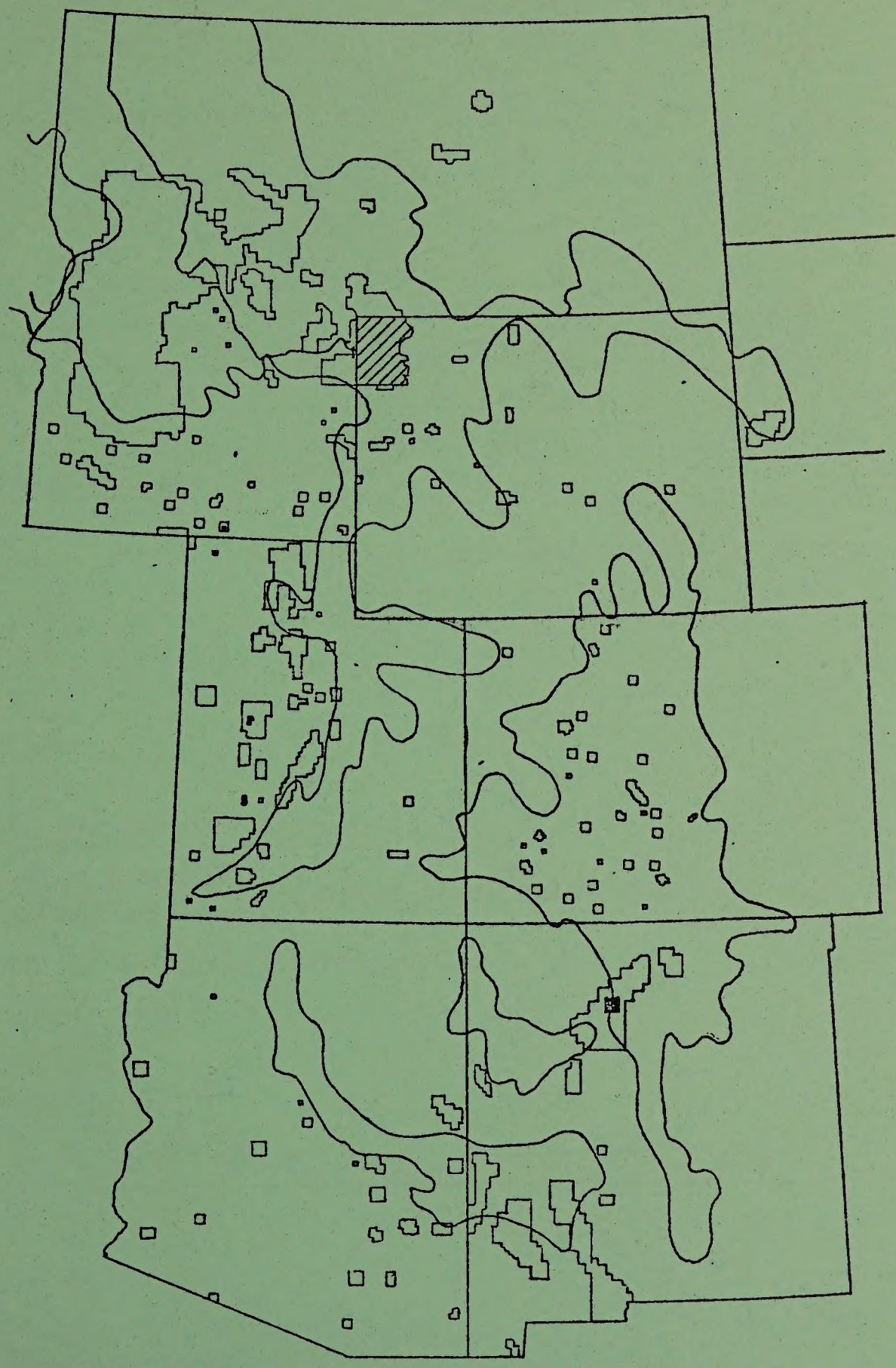
CLASSIFIED FOR GEOTHERMAL



(From USGS circular 647)

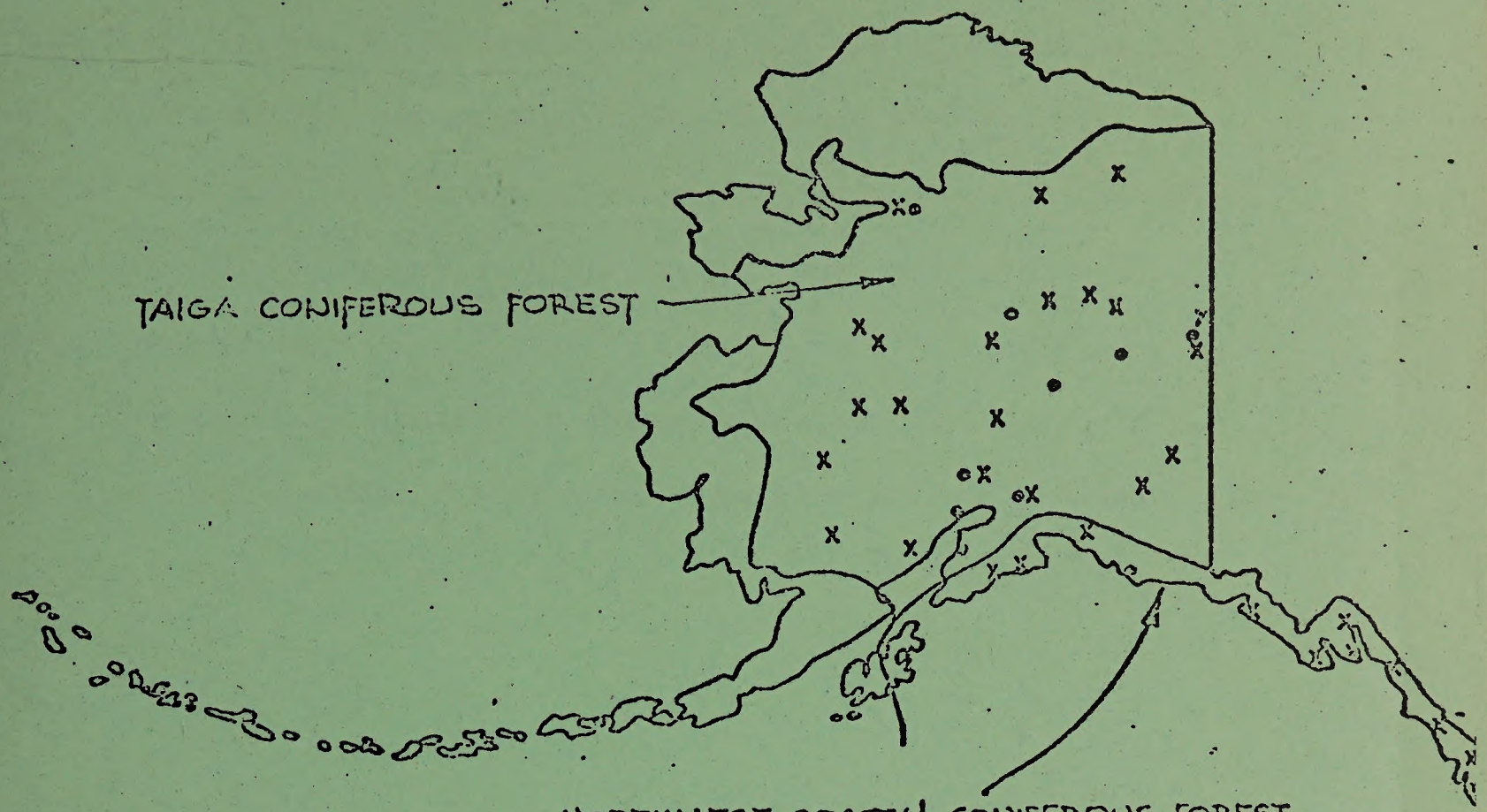
FIGURE NO. 6

...P OF THE WESTERN UNITED STATES SHOWING LANDS CLASSIFIED FOR GEOTHERMAL



(From USGS circular 647)

FIGURE NO. 7



MINERAL PRODUCING AREAS

• LEASABLE MINERALS (OTHER THAN OIL & GAS)
× LOCATABLE MINERALS

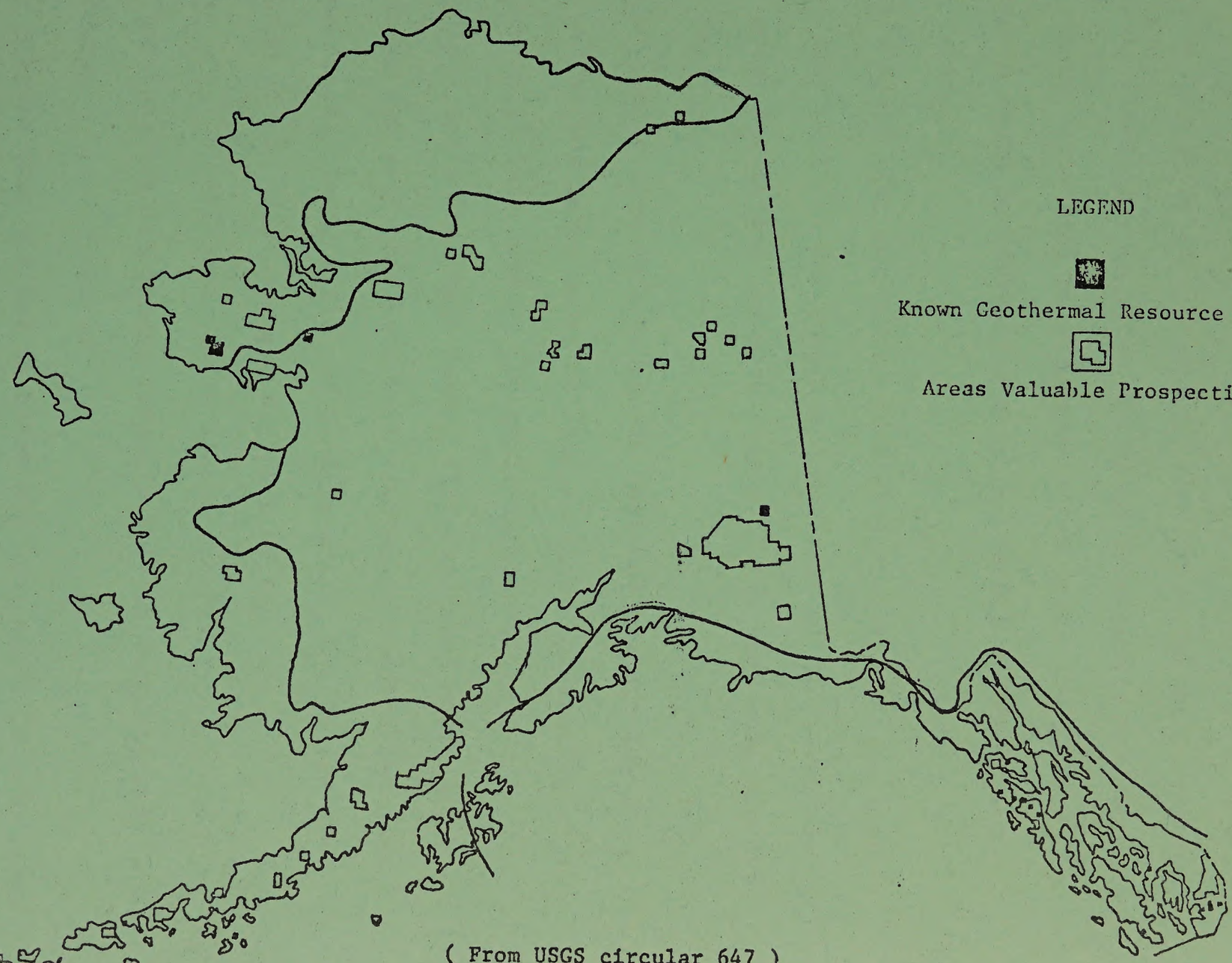
SOURCE : 1970 NATIONAL ATLAS

FIG. 8 CONIFEROUS FOREST BIOME

with the fault systems throughout the area, and are primarily of the fissure filling or vein replacement type. Some of the deposits, in particular tin, gold, silver and platinum are found as placer deposits along rivers. Barite occurs in bedded cretaceous sediments in the northwest coastal area.

The leasable minerals in these same areas include coal, geothermal steam and associated geothermal resources and oil and gas. (Fig. 9)

MAP OF ALASKA SHOWING LANDS CLASSIFIED FOR GEOTHERMAL RESOURCES EFFECTIVE DECEMBER 24,1970



LEGEND

Known Geothermal Resource Areas

Areas Valuable Prospectively

(From USGS circular 647)

FIGURE NO. 9

E. Soils

The soils in the Coniferous Forest Biome are extremely varied, ranging in depth from very shallow to very deep, from sandy to clayey in texture, and from very stony to non-stony. They occur on topography that ranges from nearly level to very steep and range from poorly drained to well drained. These soils will be discussed at an order level, which is quite broad, and is based on weathering characteristics. These orders are defined as follows:

- Alfisols - Soils that are medium to high in bases and have gray to brown surface horizons and subsurface horizons of clay accumulation; usually moist but during the warm season of the year some are dry part of the time.
- Aridisols - Soils that have pedegenic horizons and are low in organic matter and never moist as long as three consecutive months.
- Entisols - Soils that have no pedogenic horizons.
- Inceptisols - Soils that have weakly differentiated horizons; materials in the soil that have been altered or removed but have not accumulated. These soils are usually moist; but during the warm season of the year some are dry part of the time.
- Mollisols - Soils that have nearly black, friable, organic-rich surface horizons high in bases; formed mostly in subhumid and semiarid warm to cold climates.
- Ultisols - Soils that are low in bases and have subsurface horizons of clay accumulation usually moist, but during the warm season of year, some are dry part of the time.

Generally, the Northwest Coastal's major soil orders are Ultisols and Inceptisols; the Taiga's major order is Inceptisols; and the Montane's major orders are Mollisols and Alfisols. In the parts that follow the soil orders that are found throughout the Coniferous Forest Biome will be discussed first and then, when applicable, the individual sub-biomes.

1. Northwest Coastal, Taiga and Montane Coniferous Forests

Inceptisols and Ultisols generally occur in the higher elevations and areas receiving larger amounts of precipitation. Ultisols have clay enriched subsoils, are acid in nature and may have light or dark colored surfaces. Characteristics of the Inceptisols vary greatly. The soils in these two orders occur in northeastern California, western Oregon and Washington, adjacent to the Canadian border in northern Idaho and northwestern Montana, and south in the Rocky Mountains to central Idaho. Inceptisols are found throughout Alaska where mineral soils occur.

Inceptisols and Ultisols which are less than 20 inches deep and contain over 35% coarse fragments are very difficult to reforest to the desired level of stocking in the desired length of time. Productivity on these soils is low. Landslide hazard is high after disturbance when the shallow stony Inceptisols are derived from sedimentary bedrock and occur on slopes greater than 80 percent. This is especially true when they are influenced by groundwater such as in draws. Ultisols usually reflect relative stable conditions. However, landslide hazard is high after road construction if these soils are underlain by weathered bedrock.

Productivity and regeneration success are high on the deep, non-stony Inceptisols and Ultisols. Compaction hazard is high on Ultisols. Productivity is about one-half a site class lower on the dry Ultisols and Inceptisols that it is on the moist ones. Productivity also in lower on the frigid soils than the wet soils.

2. Taiga Coniferous Forest

Permafrost conditions occur discontinuously through portions of the Taiga Forests of interior Alaska. The soils of the river valleys and the lower side slopes of the mountains are covered with a thin to thick blanket of vegetative material that acts as an insulating mat. In most of interior Alaska, this mat provides protection and stabilizes the underlying soils which are a frozen or a permafrost soil. When the vegetative cover is disturbed or removed, the permafrost is exposed and during the moderate temperature short duration summer period, the exposed permafrost melts at exceedingly high rates.

3. Montane Coniferous Forest

Alfisols occur in areas receiving less rainfall than the previous two orders. Therefore, the base status is higher. Alfisols have a clay enriched subsoil and a grey to brown surface soil. The large areas of Alfisols are located on the east and west side of the Sacramento Valley in California and areas on the east front of the Rocky Mountains in Montana, Wyoming, and Colorado. Alfisols commonly occur in dry zones. These soils usually have a high hazard for compaction. Reforestation is very difficult on Alfisols when they are less than 20 inches deep, contain

over 35% coarse fragments and occur in a xeric zone. Productivity is also low in these situations. Alfisols are relatively stable unless they are underlain by decomposed or unconsolidated bedrock.

Mollisols have a high base status, have a surface enriched in organic matter and have dark colored surfaces. Mollisols are located in the southern Rocky Mountains in Utah and Arizona. Mollisols occur under dry and moist conditions as well as warm and cold conditions. Productivity decreases as Mollisols become dry and also when they become cold. Mollisols less then 20 inches deep occurring in the dry zone, and contain over 35% coarse fragments have severe reforestation problems.

Entisols are young soils lacking diagnostic horizons. They occur in areas having recent deposits of alluvium, on very steep, raveling slopes and on recently stabilized sand dunes. These soils occur in western Colorado, northwestern New Mexico and central Utah. Entisols on steep raveling slopes are unstable and have a high hazard for landslides and erosion. Most Entisols that occur on the floodplains have a high hazard for flooding.

Aridisols are generally associated with the desert as they have prolonged dry periods. However, there are small areas of Aridisols supporting coniferous forests in New Mexico and Arizona. Moisture is a limiting factor on these soils.

F. Water [12, 13, 14]

The water resources of the Coniferous Forest Biome provide most of the water needs for the western United States. In the subregions of the Columbia-North Pacific, northern California, Great Basin and the Upper and Lower Colorado, over 90% of the runoff originates in high elevation forests. The major rivers and streams which originate in forested regions also contribute to recharge of the ground water aquifers underlying adjacent biomes (grassland, desert, woodland-bushland). The generally higher elevation coniferous forests vary widely in annual precipitation received from as low as 5 inches in the extreme northern part of the Taiga Forest in Alaska to more than 200 inches at some stations along the coastal area of southeastern Alaska and northwestern Washington. Many of the coniferous forests are water surplus areas because of the large amounts of precipitation and these forests provide generous quantities of high quality water which in some areas exceeds the demand.

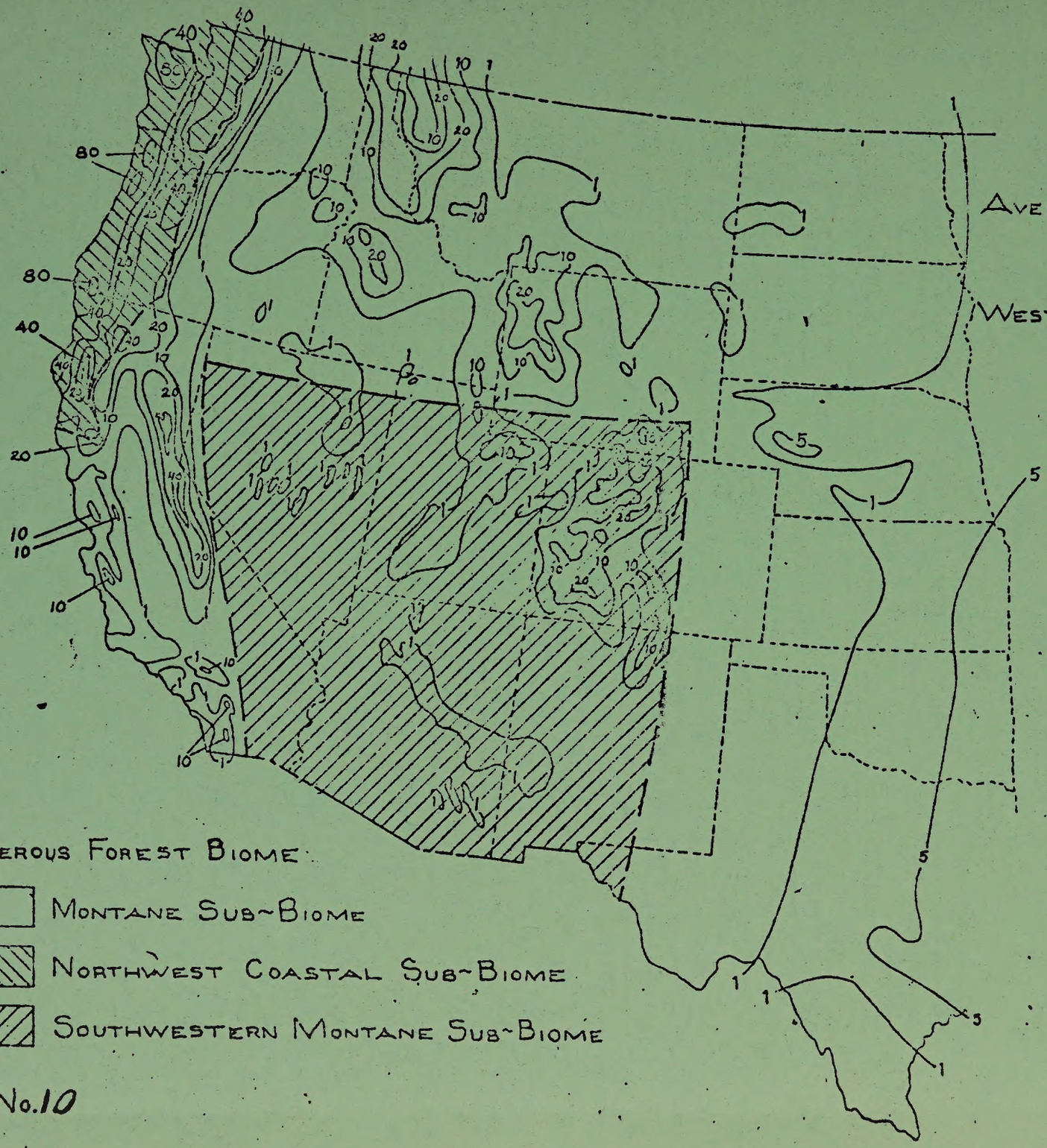
1. Surface Water

The large quantities of water found in the Coniferous Forest Biome occur as streams, rivers, lakes, reservoirs, springs, marshes, muskeg, and pot holes. These water resources are extremely important for many uses including power generation, industrial, municipal, agricultural, recreation and fish and wildlife. One measure of the importance of this resource is given by the large number of international, interstate, intrastate, and interagency agreements on the disposition of water for various uses.

Water yield from coniferous forests shows extreme regional variation ranging from about 1 inch per year in the southwestern Montane (Fig. 10) to over 200 inches at some locations in the Northwest Coastal on the southeastern Alaska coast. Along the lower elevation coastal areas of the Northwest Coastal in northern California, Oregon and Washington, where much of the precipitation occurs as winter rainfall, most of the runoff comes during the period of November through March. The runoff from mountainous areas adjacent to the Gulf of Alaska shows little seasonal variation since streamflow is derived from both rainfall and snowmelt.

The Taiga in the interior of Alaska has low runoff rates and progressively shorter summer runoff seasons with increasing latitude. In these areas 80% to 95% of the annual runoff occurs during the 5-month period from May to September. In this area permafrost restricts subsurface drainage, creates extensive areas of wetlands and muskeg, and restricts groundwater recharge. As a result, many streams have little or no winter-flow. Severe annual floods, complicated by ice jams, are characteristic throughout this region. Large areas are inundated each year by overbank flow, which requires evacuation of villages along the rivers. Ice scouring contributes to heavy debris and sediment loads during the spring breakup.

Many parts of the northern Montane region produce surpluses of good quality water (see Fig. 11). Most of the runoff appears in response to snowmelt and spring rains. This region has a low runoff period from



Average Annual Runoff
for the
Western United States

Figure No. 10

Areas of Natural Water Surplus and Natural Water Deficiency

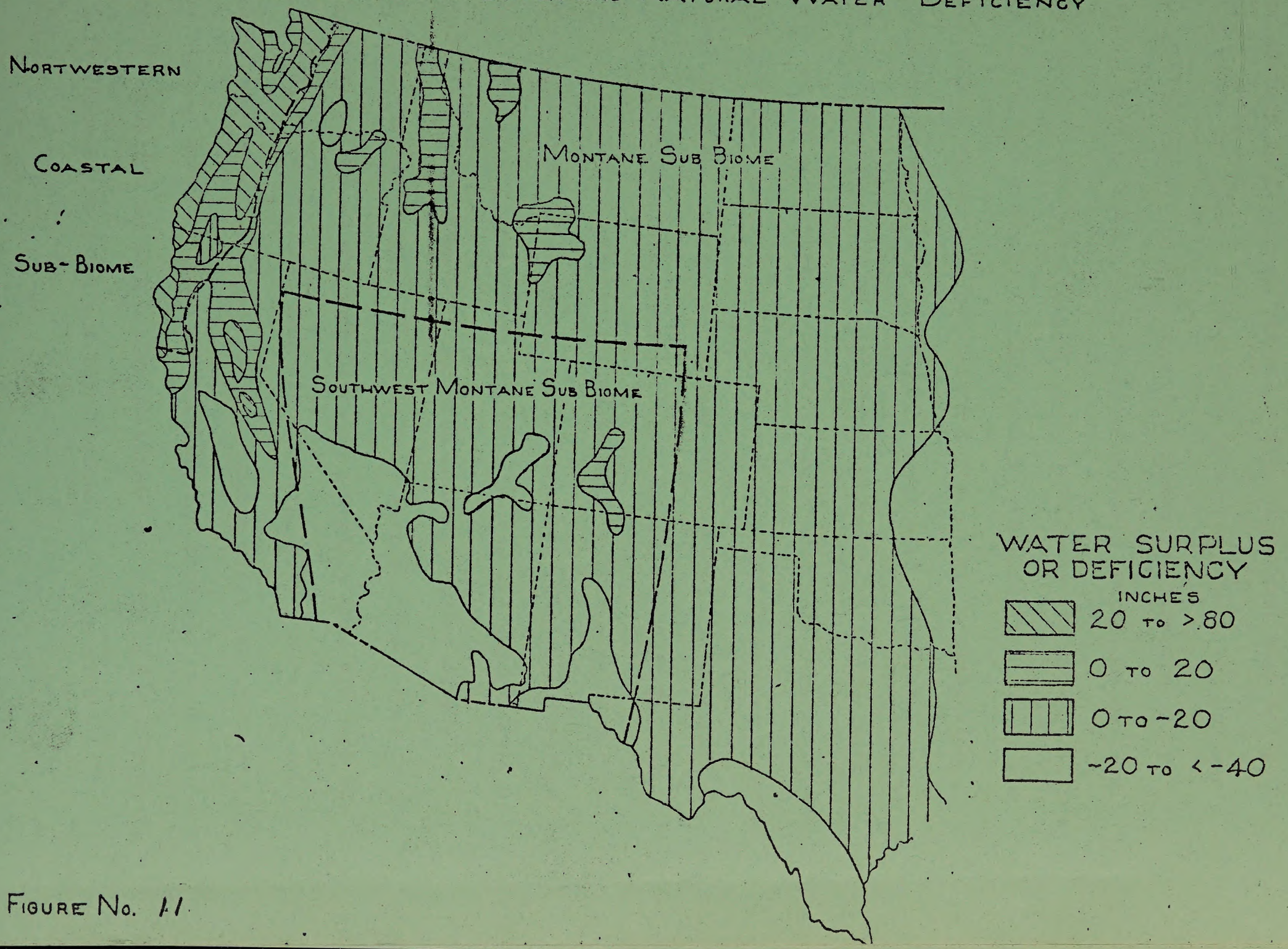


Figure No. 11

late summer through late spring. Figure 4 also shows that much of the region has a water deficiency of from 0 to 20 inches, where the demands on water exceed the supply by this amount. Streamflow from the southwestern Montane region depends heavily upon snowmelt contributions from the high elevation coniferous forests. For example, in the upper Colorado River basin 75% of the streamflow originates as snowmelt from 33% of the area of this region which is in coniferous forest or above timberline.

Research is currently underway in forests of the Sierras on augmentation of water supplies by vegetative manipulation in the upper timber zone. Harvesting timber in patterns which encourage greater snowpack accumulation has resulted in an increased water yield of over 4 inches in operational programs. Forest management for augmentation of runoff is also found in the southwestern Montane forests of the Colorado Rockies.

Water quality is generally good throughout the Taiga except for two specific situations, (1) sediment contribution of glacier-fed streams is high, and (2) waters derived from extensive muskeg and swamp areas are unusually high in organic compounds and iron content because of the restricted subsurface drainage. The quality of most surface waters in the Northwest Coastal in Oregon and Washington is generally good with concentration of dissolved solids less than 120 ppm (Fig. 12). Similar low concentrations may be found in the northern Montane along the Cascades, the Sierras, and in northern Idaho and northwestern Montana. Concentration of dissolved solids is much higher in streamflow from the southwestern Montane. This decrease in water quality is caused by lower annual

CONCENTRATION OF DISSOLVED SOLIDS IN STREAMFLOW

DISSOLVED SOLIDS IN STREAMFLOW

- LESS THAN 120 PPM
- 120 TO 350 PPM
- MORE THAN 350 PPM

MEASURED IN PARTS PER MILLION

FIGURE NO. 12

120

precipitation, greater evaporation and geologic material which is more easily soluble in water.

Sediment concentration in streamflow is generally low in streamflow in the Taiga, the coastal areas and much of the northern Montane region (Fig. 13). Exceptions are glacial streams in Alaska (as already noted) and around Mt. Rainier in Washington. Streamflow in the southwestern Montane is more likely to have higher sediment concentrations because of the higher incidence of summer thunderstorms and because much of the geologic material is relatively easy to erode. An exception to this is the area around the Colorado Rockies which is composed of relatively hard rock.

Total nitrogen content of streams draining coniferous forest lands averages about 0.5 parts per million. By contrast, a stream draining agricultural lands may contain twice this concentration of nitrogen.

The dissolved oxygen content of water depends upon temperature, turbulence of flow (which entraps atmospheric oxygen) and the amount of organic material in the water which requires oxidation. The capacity of water to hold dissolved oxygen decreases as water temperature increases, as the turbulence of stream flow decreases (because of reduced entrapment of oxygen) and as the amount of organic material in the stream increases.

2. Groundwater

Large quantities of groundwater are known to be available throughout most of the Yukon River flood plain in the Taiga region of

CONCENTRATION OF SEDIMENT IN STREAMS

CONCENTRATION OF SEDIMENT

- Less Than 270PPM
- 270 to 1900 PPM
- 1900 or More PPM

MEASURE IN PARTS PER MILLION

FIGURE No. 13

Alaska. Little use is presently being made of this resource because settlement and industry are almost non-existent. In portions of the region which are underlain by permafrost, groundwater is extremely difficult to obtain. High salinity is a problem in the northern part of the Taiga.

Groundwater is limited in the Northwest Coastal region of Alaska where steep mountains, rapid runoff, and a lack of surficial deposits to store and retain groundwater preclude its use. Groundwater aquifers in the Northwest Coastal are composed of alluvial valley fills surrounded by forested mountains from which they receive runoff replenishment. One of the largest of these aquifers is within the Willamette Valley-Puget Sound Trough in Oregon and Washington (Figure 14). The Northwest Coastal also overlaps another alluvial groundwater aquifer in northern California, where runoff from forested watersheds replaces annual groundwater pumpage. Smaller alluvial aquifers within valleys provide a source of groundwater for municipal and industrial use at many locations in the northern Montane region. An important source of replenishment for these aquifers is infiltration of water from streams which arise in the coniferous forests.

MAJOR AREAS OF POTENTIAL GROUNDWATER DEVELOPMENT

FIGURE No. 14

124

G. Climate and Air

A dense forest, says Zon, is like an enormous umbrella with holes in it, covering the earth. [15] It is to be expected that the elements of climate -- moisture, temperature, light, air movement -- are modified under such a cover. Moreover, the climate adjacent to but not under the umbrella is also somewhat modified. It follows that, even though man can do little or nothing to affect the climate in general, he can influence it to some extent locally by adding or removing forest cover. [16]

Different kinds of forests have different effects, but numerous observations have shown that, in general, the sub-biomes of the Coniferous Forest Biome have certain local climatic effects in common. Some of these effects are as follows: [16]

- The mean maximum monthly air temperature in the forest is about 4°F. lower during the summer than the temperature outside; in winter, it is about 2° lower.
- Forest soil is warmer by 2° in winter and 5° to 9° cooler in summer than soil outside the forest, and freezing, if any, is significantly less deep than outside.
- Sunlight intensity is reduced 50 to 90 percent within the forest, the amount of reduction depending on the density of the forest cover and its species composition (kinds of trees constituting the forest).

- A considerable amount of total precipitation is intercepted by the forest crown and evaporates before it can reach the ground.
- The relative humidity of the air is greater within the forest than outside by 3 to 12 percent. Evaporation from the soil under the forest is greatly reduced, and the water-storing capacity of the soil greatly increased.
- Air temperature differentials between forests and adjoining open areas cause air movement between forests and fields. These air currents facilitate the formation of dew and fog over adjoining fields; these in turn save the fields from spring and fall frosts and summer hail damage.
- Wind velocities are immensely reduced within the forest.

If forests affect climate to some extent, climate affects forests to a far greater extent. Climate and soils are the two major factors which have determined the location and character of the great forest zones of the world. [17]

The geographical occurrence of the Coniferous Forest Biome, and its species composition, are influenced to a large extent by moist air masses moving easterly from the mild temperatures of the Pacific Ocean's Japan Current; [18] by polar air masses originating over the Arctic Ocean, interior Alaska and northwestern Canada; and by extensive mountain ranges that modify marine air from the Pacific, act as barriers to incursions of polar or tropical air, and support, on their slopes, climatic conditions which vary with changes in elevation, latitude, soil, exposure and land form.

Significant climatic differences within the biome require separate discussion, as follows.

1. Northwest Coastal Coniferous Forest

This sub-biome is characterized by heavy rainfall during late autumn, winter and spring. Moist winds from the Pacific Ocean have given rise to the forests of this region.[19] July and August are generally the driest months; December and January the wettest[20] (see Figures 8, 9 and 10). Average annual precipitation ranges from 20-25 inches in the San Francisco area[21] and 60-140 inches on the Olympic Peninsula of Washington, to 60-160 inches on the southern and southeastern coast of Alaska[22] (Figure 11). More than two-thirds of this annual precipitation falls during the period from October 1 to March 31.

Low temperatures range from -25°F. on the southern coast of Alaska to 25° at Oakland, California;[23] high temperatures can exceed 90° throughout the sub-biome[24]. Mean monthly temperatures range from 25° (Alaska coast) and 45° (California coast) in midwinter, to 55° (Alaska coast) and 65° (California coast) during July.[25] The length of growing season (period between last killing frost in spring and first killing frost in fall) ranges from more than 300 days in the southern latitudes of the sub-biome to as little as 100 days along the Alaska coast.[26]

During the winter months, coastal southwesterly winds sometimes attain hurricane force, causing extensive damage to forest stands. Northerly winds prevail in summer. Thunderstorms are infrequent.

2. Montane Coniferous Forest

In this sub-biome the elevation and latitude are major climatic influences; the higher and more northerly the location, the colder and wetter the climate. There is also a general decrease in precipitation from west to east, which is related to increasing distance from the Pacific Ocean. The oceanic influence is fairly strong on the east slopes of the Cascade Mountains in Washington and Oregon, and in the Sierras of California. The Rocky Mountain area in general has a continental climate. However, the northern part of the intermountain area (that portion of the sub-biome which lies within the Columbia River basin) is rather strongly affected by Pacific air masses which penetrate the Cascades via the Columbia River gap and move eastward and northeastward across the intermountain plateau to the western slopes of the northern Rockies.

Annual precipitation at the lower forested elevations (3000-4000 feet) generally averages about 16 inches a year. At the higher elevations, approximate annual average precipitation in the Sierras of California is 50 inches, in the Cascades of Washington and Oregon 90 inches and in the Rockies 30 inches (Figure 15). Average January precipitation varies from 8 inches along the Sierras and Cascades to 1-3 inches in the Rockies. July precipitation averages 1 inch or less in the Sierras and Cascades and 2-3 inches in the Rockies (Figure 16 & 17).

Nearly all winter precipitation at the higher elevations occurs as snowfall. Snow depths are periodically measured at fixed locations, as basis for predictions of spring and summer streamflow at lower elevations.

AVERAGE ANNUAL PRECIPITATION

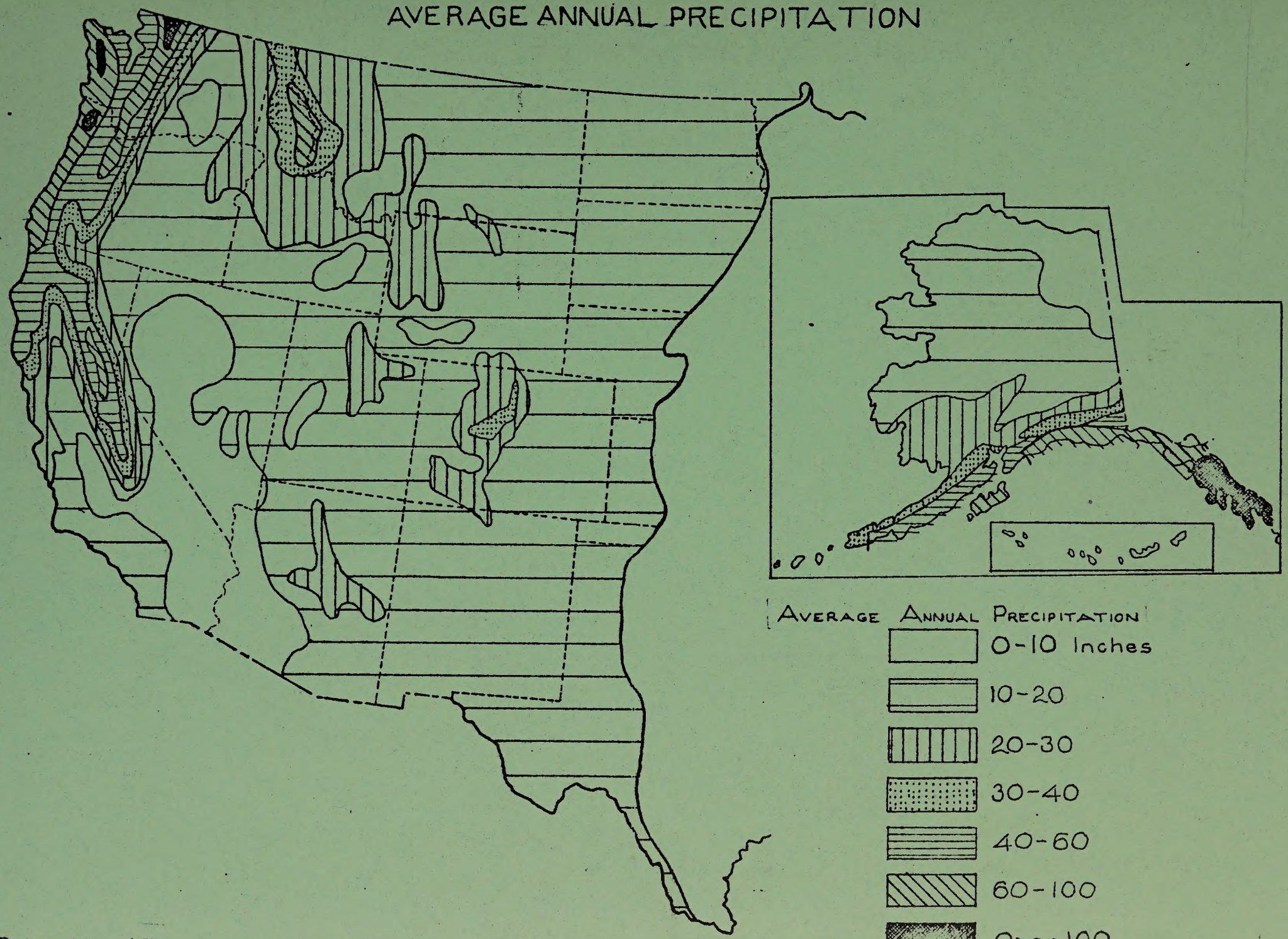


FIGURE NO. 15

MONTHLY PRECIPITATION (INCHES)-JULY

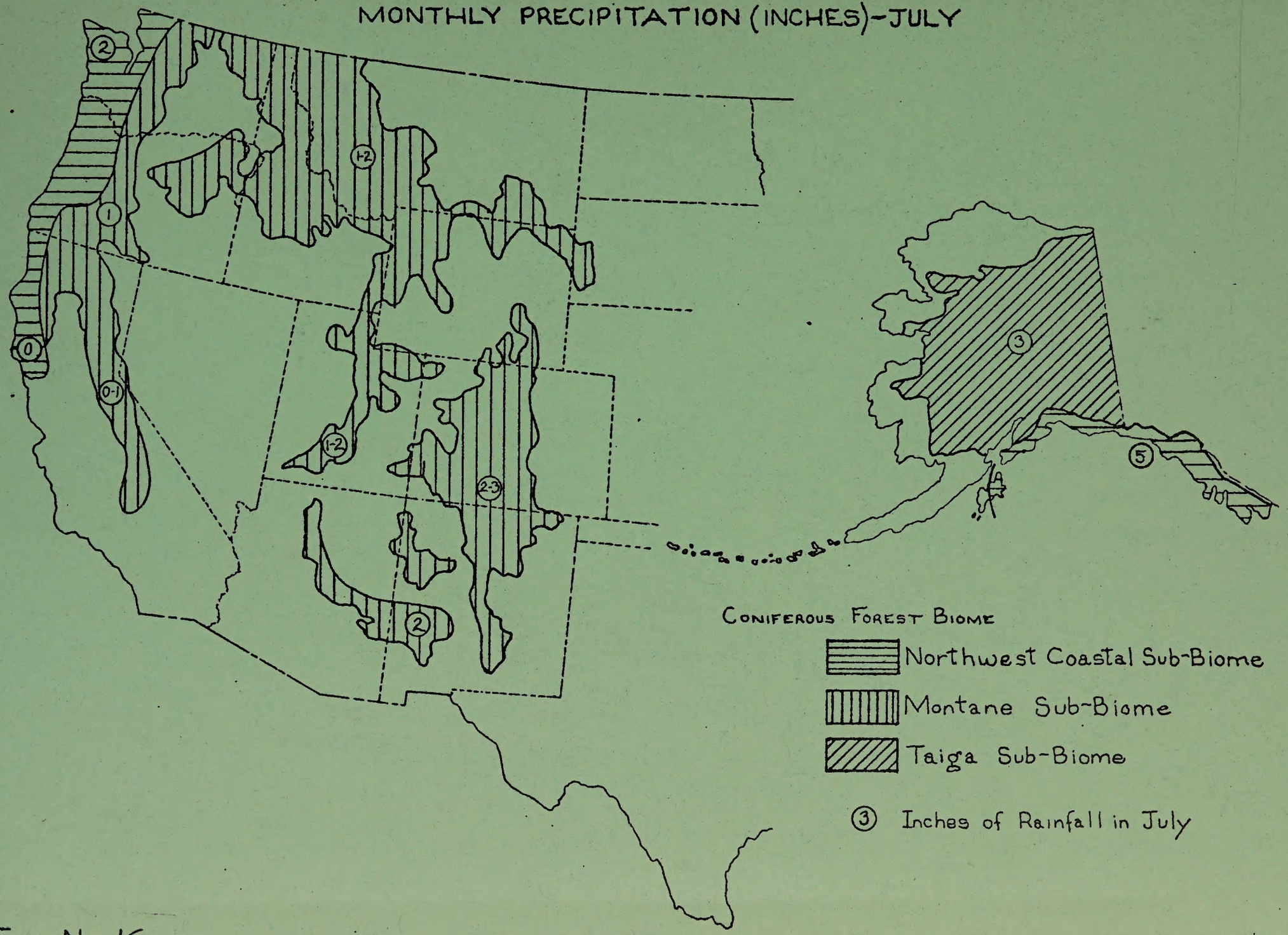
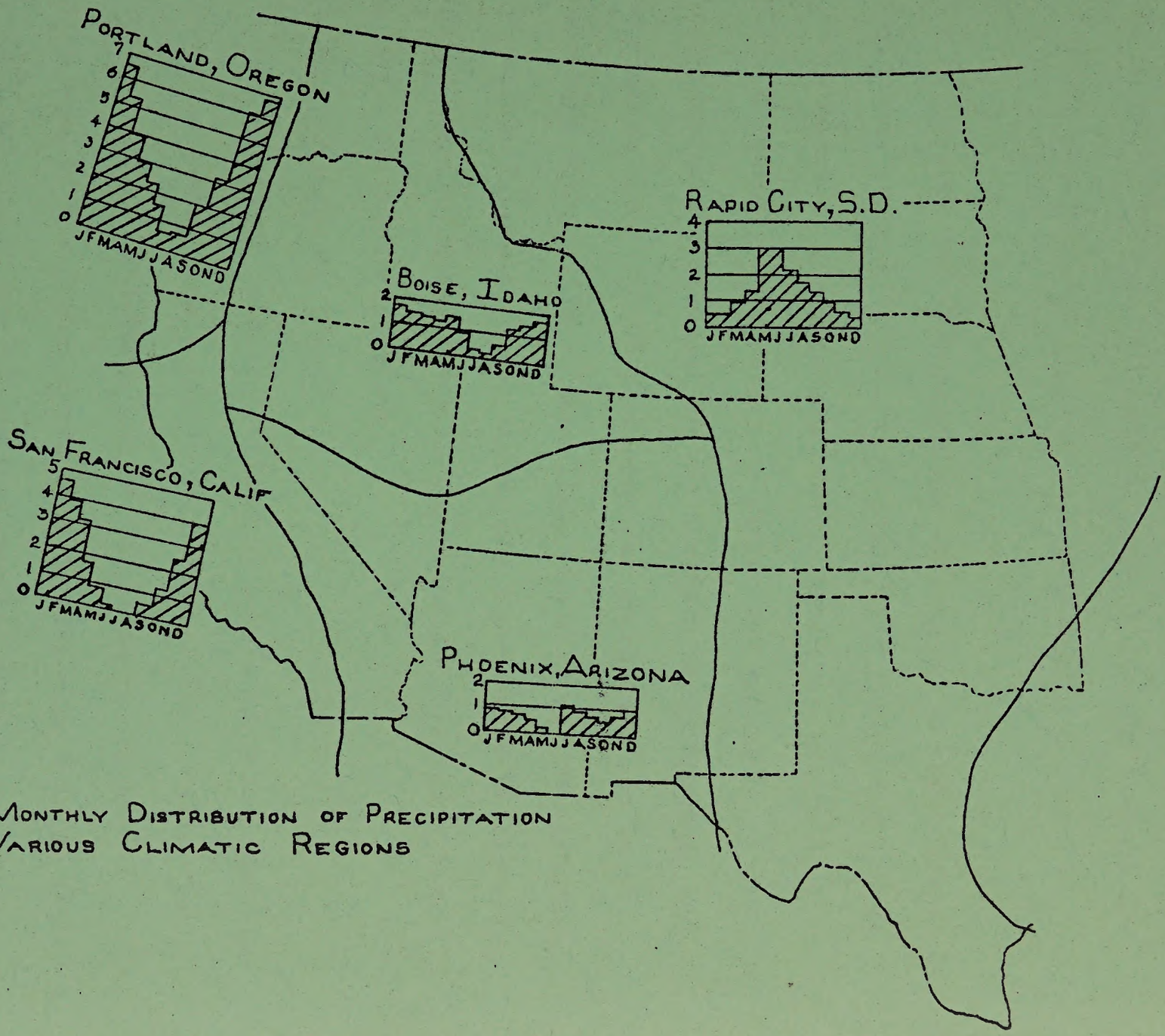


Figure No. 16

MONTHLY PRECIPITATION



TYPICAL MONTHLY DISTRIBUTION OF PRECIPITATION
IN VARIOUS CLIMATIC REGIONS

FIGURE No. 17

Average temperatures during January range from about 30° at the lower elevations and southern latitudes to 10° at the higher elevations and northern extremes of the sub-biome. Mean July temperatures vary from 60° to 75°. [26] Maximum length of growing season is about 200 days (lower elevations, southern latitudes), minimum length about 60 days. [26]

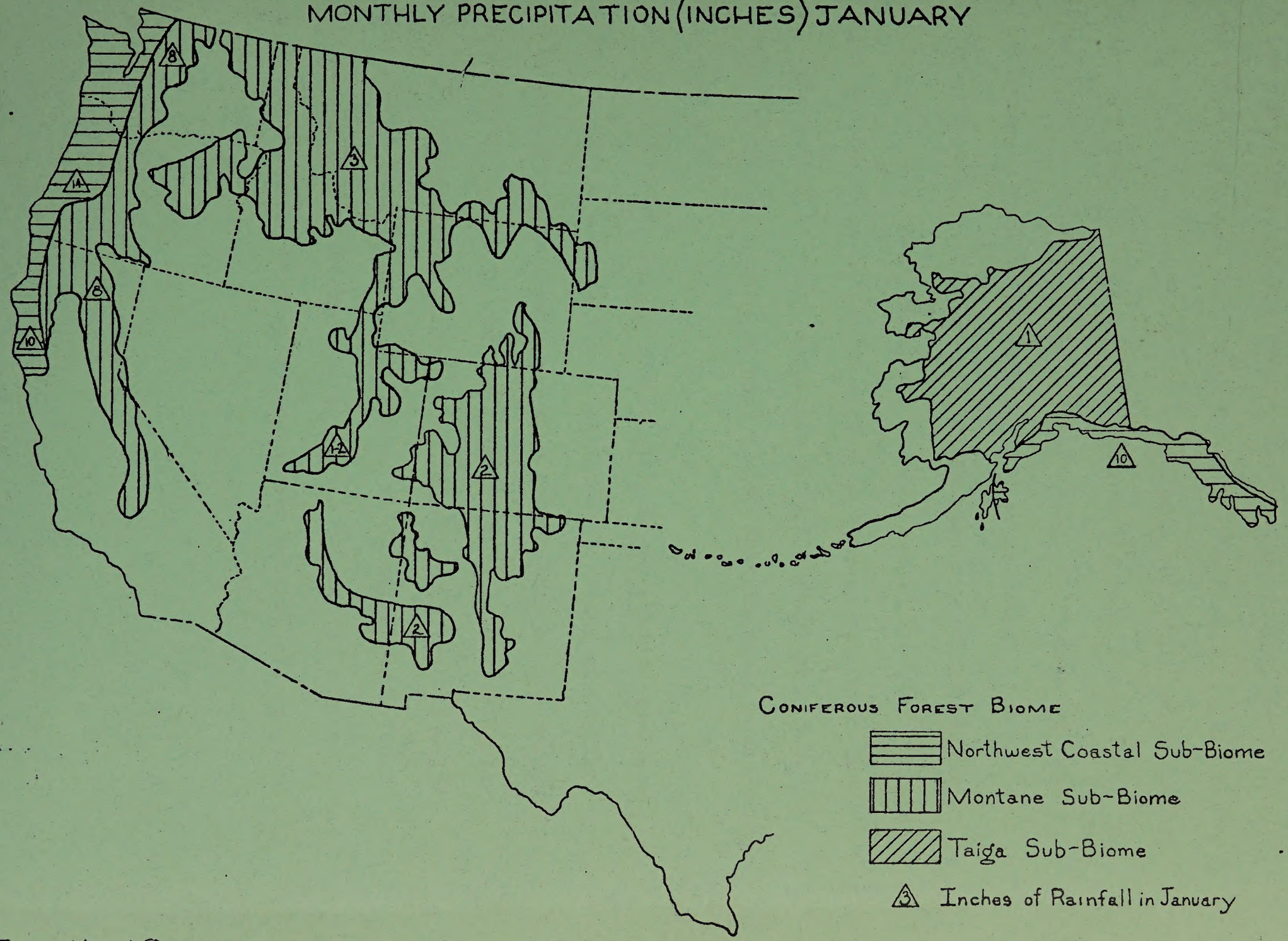
Wind directions and velocities are influenced by topography. There is considerable convective activity, especially during the summer months. At the summits of the mountain ranges, winds are generally from the west and are frequently very strong in winter and spring.

Thunderstorms are frequent in the northern Rocky Mountain and intermountain plateau areas (40-50 thunderstorms annually), and in the central and southern Rockies (50-70 annually). Usually occurring during the warm, dry months of summer, these storms are accompanied by lightning activity which frequently causes fires in inaccessible forested areas, thus creating major protection problems.

3. Taiga Coniferous Forest

This sub-biome is characterized by severe winters. Average annual precipitation varies from 7 inches in the upper Yukon Valley (at Fort Yukon) to 12 inches at Fairbanks and 16 inches in the Matanuska Valley, although some of the higher elevations receive more than 30 inches (Figure 15). July and August are the wettest months, January one of the driest [27] (Figure 18).

MONTHLY PRECIPITATION (INCHES) JANUARY



CONIFEROUS FOREST BIOME

Northwest Coastal Sub-Biome

Montane Sub-Biome

Taiga Sub-Biome

3 Inches of Rainfall in January

FIGURE No. 18

Low temperatures range from -35° in the Matanuska Valley to -78° in the Yukon basin (at Fort Yukon). High temperatures of 91° in the Matanuska Valley and 100° at Fort Yukon have been recorded. Mean monthly temperatures vary from a low of -22° in January (at Fort Yukon) to 60° in July (at Fairbanks). Growing season lengths range from about 63 days (minimum) at McKinley Park to as much as 93 days at Bethel. [27]

The possible daily hours of growing season sunshine vary with latitude. In June, the lower latitudes can receive 16 hours of sunshine per day, northern portions of the sub-biome 24 hours. However, cloud cover limits the amount of solar radiation actually received. Even in interior Alaska there are nearly as many cloudy days as clear ones during the growing season. [28]

Over much of the Taiga, severe climate and organic (peat) soils have combined to create a condition of permanently frozen ground (permafrost). This is the tundra, where the mean temperature of the warmest month is below 50°F., and only the top layer of soil thaws during the warm season. [29] The southern limit of continuous permafrost lies just south of the Brooks Range, the timberline of which marks the northern boundary of the Taiga Coniferous Forest. South of the continuous permafrost area, discontinuous permafrost occurs over most of the Taiga to its southern limit. [30]

H. Vegetation

1. Terrestrial Vegetation

Coniferous trees are the predominant form of vegetation, covering extensive areas, ranging from the Pacific Coast, including Alaska, to the eastern foothills of the Rocky Mountains. Within the Coniferous Forest Biome, the identifying life-form is the needle-leafed evergreen tree; especially the spruces, firs, pines, Douglas-fir, hemlocks and "cedars"; one of more of which are predominant in forest stands. This description therefore concentrates heavily upon the forest; associated plant communities such as alpine meadows are only briefly mentioned or omitted entirely.

For the purpose of describing vegetation, the Montane Sub-Biome has been subdivided into two regions. Each region in turn is stratified into vegetational "zones" as influenced primarily by elevation. The Northwest Coastal Sub-Biome is divided directly into vegetational zones, omitting the regional breakdown. Two general types of forests are generally recognized in the Taiga.

Within each vegetational zone, numerous plant communities exist, some of which may be identifiable on the basis of species (trees, shrubs and herbs) present and their abundance. Since these plant communities develop in relation to the sum of environmental factors acting on the specific forest area, they may therefore be used (given adequate knowledge) to indicate the presence of such factors.

Throughout the Biome, the ease by which new forests can be regenerated, may be predicted by determining whether environmental factors combine to produce a relatively "cool and moist" site or a relatively "warm and dry" one. Accordingly, this section identifies plant species generally adapted to these two categories for zones where information is readily available.

a. Taiga Coniferous Forest

Vegetation in interior Alaska [31] forms a mosaic of patterns that is related in part to past fire history, to slope and aspect, and to the presence or absence of permafrost. Two general forest classifications are recognized:

(1) White Spruce Forest

Spruce-hardwood forests with closed canopies are typical of "warm" dry uplands (east, south and west exposures) and well drained flood plains along glacial rivers. This forest is characterized by the usual successional process of (1) fire, to (2) hardwoods such as willow (Salix), quaking aspen (Populus tremuloides), paper birch (Betula papyrifera) and balsam poplar (Populus balsamifera) to (3) white spruce (Picea glauca). Other hardwoods and shrubs common at some point during the successional period include alder (Alnus), bearberry (Arctostaphylas uva-vrsi), red-fruit bearberry (A. rubra), Labrador tea (Ledum groenlandicum), narrowleaf Labrador tea (L. decumbens), American red currant (ribes triste), prickly rose (Rosa ocicularis), willow (Salix), buffalowberry (Shepherdia canadensis), mountain cranberry (Vaccinium vitis-idaea), bog blueberry

(V. uliginosum), high bushcranberry (Viburnum edule), and dwarf blueberry (Vaccinium caespitosum). The forest floor is usually carpeted with a thick moss mat.

(2) Black Spruce Forest

"Open, low growing spruce forests" are typical of north facing slopes and poorly drained lowlands, usually underlain by permafrost. This forest generally lacks the successional characteristic of the previously described forest since the major forest tree, black spruce (Picea mariana) is a pioneer species. Tamarack (Larix laricina) and white spruce (Picea glauca) are associated needle-leafed trees. Common hardwoods and shrubs include paper birch (Betula papyrifera), red-fruit bearberry (Arctastaphylos ura-ursi), crowberry (Empetrum nigrum), Labrador tea (Ledum groenlandieum), prickly rose (Rosa acicularis), willow (Salix), bog blueberry (Vaccinium uliginosum), and mountain cranberry (V. vistis-idaea). Subordinate vegetation consists of a thick moss mat, sedges, grasses and the above shrubs.

b. Northwest Coastal Forest

This is the most densely forested region in the coniferous biome. Forests generally regenerate easily and quickly, grow rapidly and reach impressive sizes. Mature forests usually have lush understory, shrub and herbaceous layers comprised of shade tolerant conifers, shrubs, ferns, other herbs, mosses and liverworts.

Plant succession in the Northwest Coastal sub-biome following removal of forest vegetation usually proceeds through three stages,

(1) rapid growth of residual and invading herbaceous plants (such as grasses and ferns), (2) gradual development into a shrub dominated condition and (3) development of the young growth forest. Stages one or two, or both may not occur depending upon environmental factors. Either of the first two stages may also dominate for exceedingly long periods of time, also due to environmental factors. There is an expecially strong tendency to develop dense shrub and hardwood communities of moisture loving species (such as alder, salmonberry and huckelberry) where moisture is abundant.

Franklin and Dyrness have identified five major coniferous dominated vegetation zones within the sub-biome; they include (1) the coastal "Sitka Spruce Zone", (2) the widespread inland low to mid-elevational "Western Hemlock Zone", (3) the higher elevational "Pacific Silver Fir Zone", (4) the sub-alpine "Mountain Hemlock Zone", and (5) "Timberline". [32]

Major tree species found within the Northwest Coastal Sub-Biome and this occurrence within the major zones are shown on Table I and are estimated as follows: 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent.

TABLE I

NORTHWEST COASTAL SUB-BIOME

SPECIES OCCURRENCE BY ZONES

Species	* Sitka Spruce	* Western Hemlock	ZONES Pacific Silver Fir	Mountain Hemlock	Timber-line
Western White Pine (Pinus monticola)	4	3	2	3	4
Sugar Pine (Pinus lambertiana)	4	3	3	3	4
Whitebark Pine (Pinus albicaulis)	4	4	4	2	1
Lodgepole Pine (Pinus contorta)	1	4	2	3	3
Ponderosa Pine (Pinus ponderosa)	4	3	4	4	4
Western Larch (Larix occidentalis)	4	4	3	3	4
Engelmann Spruce (Picea engelmannii)	4	4	2	2	2
Sitka Spruce (Picea sitchensis)	2	3	4	4	4
Western Hemlock (Tsuga heterophylla)	1	1	2	3	4
Mountain Hemlock (Tsuga mertensiana)	4	4	2	2	2
Douglas-fir (Pseudotsuga menziesii)	1	1	2	3	4
Grand Fir (Abies grandis)	2	2	3	4	4
Pacific Silver Fir (Abies amabilis)	4	3	1	2	3
White Fir (Abies concolor)	4	4	4	4	4
Noble Fir (Abies procera)	4	3	2	3	4
Shasta Red Fir (Abies magnifica)	4	4	3	3	3
Subalpine Fir (Abies lasiocarpa)	4	4	2	2	2
Redwood (Sequoia sempervirens)	2	4	4	4	4
Incense-Cedar (Libocedrus decurrens)	3	2	3	4	4
Western Redcedar (Thuja plicata)	2	2	3	4	4

* zones containing significant amounts of BLM acreage.

Throughout the Sitka Spruce and Western Hemlock zones (both more commonly known together as the Coastal Douglas-fir region) which are the predominant zones, relatively "cool-moist" and "warm-dry" sites may be indicated by the presence (usually in abundance) of the following species in forest stands:

TABLE II

Species (X=Presence)	SITE	
	Cool-Moist	Warm-Dry
TREES (C = Canopy only, R = Reproducing under canopy)		
Douglas-fir (Pseudotsuga menziesii)	X(C)	X(R)
Incense Cedar (Libocedrus decurrens)		X
Ponderosa Pine (Pinus ponderosa)		X
Sitka Spruce (Picca sitchensis)	X	
Western Hemlock (Tsuga heterophylla)	X	
Western Redcedar (Thuja plicata)	X	
BROADLEAF TREES OR SHRUBS		
Red Alder (Alnus rubra)	X	
Pacific Madrone (Arbutus menziesii)		X
Golden Chinkapin (Castanopsis chrysophylla)		X
Oregon White Oak (Quercus garryana)		X
Ocean spray (Holodiscus discolor)		X
Salal (Gaultheria shallon)		X
California hazel (Corylus cornuta calif.)		X
Rhododendron (Rhododendron macrophyllum)		X

Poison Oak (Rhus diversiloba)		X
Rose (Rosa)		X
Creeping snowberry (Symphoricarpos mollis)		X
Devils Club (Oplopanox horridum)	X	
Salmonberry (Rubus spectabilis)	X	
Oregon Myrtle (Umbellularia California)	X	
HERBS		
Swordfern (Polystichum munitum)	X	
Deerfern (Struthiopteris spicant)	X	
Ladyfern (Athyrium filix-femina)	X	
Brackenfern (Pteridium aquilinum)		X
White Inside-Out Flower (Vancouveria hexandra)	X	
Three Leaved Coolwort (Tiarella trifoliata)	X	
Sweetscented Bedstraw (Galium triflorum)	X	
Oregon Oxalis (Oxalis oregana)	X	
Whipple Vine (Whipplea modesta)		X

Port Orford cedar (Chamaecyparis lawsoniana) is a natural component of timber stands on sites of almost any moisture regime in extreme southwestern Oregon. It is currently endangered by a killing root disease, however, to the extent that it has nearly been eliminated from moist sites and could possibly be eliminated from most of its natural range.

c. Montane Coniferous Forest

This sub-biome, scattered over extensive areas in the mountainous regions of the contiguous western states, differs from the adjacent Northwest Coastal Forest in that it generally reproduces with difficulty or grows slowly, has a relatively open canopy and tends to have sparce understory, shrub and herbaceous layers (exceptions are commonplace). Plant succession in this sub-biome visually follows the three stages outlined for the Northwest Coastal Forest (herbs to shrubs to trees). To facilitate the vegetative description, the Montane Sub-Biome is divided into two regions, (1) "Southwestern Oregon - Northwestern California - Sierra Nevada", and (2) "Eastern Oregon - Eastern Washington - Rocky Mountains."

(1) Southwestern Oregon - Northwestern California - Sierra Nevada

This region may be viewed as having six major elevational forest zones.[33, 34, 35] These are: (1) the Sierra's "Ponderosa Pine Zone", (2) the "Mixed Conifer and Mixed Evergreen Zone", (3) the "White Fir Zone", (4) the "Red Fir Zone", (5) the "Mountain Hemlock Zone", and (6) "Timberline". With one major exception, these zones are generally in elevational sequence where elevational differences are sufficient to include them. The exception is in southwestern Oregon and northwestern California where the Ponderosa Pine Zone is absent.

Major tree species found within this region and their occurrence within the major zones are estimated as shown on Table III and are as follows: 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent.

TABLE III

MONTANE SUB-BIOME

SPECIES OCCURRENCE BY ZONE

S.W. Oregon - N.W. Calif. - Sierra Nevada Region

Species	* Pond. Pine	* Mixed C. or E.	* White Fir	Red Fir	Mount. Hem.	Timber-line
	ZONES					
Western White Pine (Pinus monticola)	4	3	3	3	3	4
Sugar Pine (Pinus lambertiana)	2	2	3	3	3	4
Whitebark Pine (Pinus albicaulis)	4	4	4	3	2	1
Lodgepole Pine (Pinus contorta)	2	3	3	3	2	2
Ponderosa Pine (Pinus ponderosa)	1	2	3	4	4	4
Jeffrey Pine (Pinus jeffreyi)	2	3	3	4	4	4
Engelmann Spruce (Picea engelmannii)	4	4	4	3	3	3
Western Hemlock (Tsuga heterophylla)	4	3	4	4	4	4
Mountain Hemlock (Tsuga Mertensiana)	4	4	4	3	1	2
Douglas-fir (Pseudotsuga menziesii)	2	2	2	4	4	4
Grand Fir (Abies grandis)	3	3	4	4	4	4
Pacific Silver Fir (Abies amabilis)	4	4	3	2	4	4
White Fir (Abies concolor)	2	2	1	3	4	4
Noble Fir (Abies procera)	4	4	4	3	4	4
Shasta Red Fir (Abies magnifica)	4	4	3	1	2	3
Subalpine Fir (Abies lasiocarpa)	4	4	4	3	2	2
Incense-Cedar (Libocedrus decurrens)	2	2	2	3	4	4
Western Redcedar (Thuja plicata)	4	3	3	4	4	4

* zones containing significant amounts of BLM acreage.

Within the "Mixed Conifer - Mixed Evergreen" and possibly within the White Fir Zones, which are the predominant zones, relatively "cool-moist" and "warm-dry" sites may be indicated by the following plants (usually in abundance) in forest stands: [36, 37]

TABLE IV

Species (X = Presence)	SITE	
	Cool-Moist	Warm-Dry
TREES		
Shasta Red Fir (Abies magnifica)	X	
Incense-Cedar (Libocedrus decurrens)		X
Western Hemlock (Tsuga heterophylla)	X	
Western Redcedar (Thuja plicata)	X	
Tanoak (Lithocarpus densiflorus)		X
Pacific Madrone (Arbutus menziesii)		X
Golden Chinkapin (Castanopsis chrysophylla)		X
Canyon Live Oak (Quercus chrysolepis)		X
Oregon White Oak (Quercus garryana)		X
Calif. Black Oak (Quercus kelloggii)		X
SHRUBS & HERBS		
Poison Oak (Rhus diversiloba)		X
Rose (Rosa)		X
Trailing Blackberry (Rubus ursinus)		X
Vine Maple (Acer circinatum)	X	
Pacific Dogwood (Cornus nuttallii)	X	

California Hazel (Corylus cornuta calif.)	X	
Squaw Carpet (Ceonothus prostratus)		X
Oregon Grape (Berberis nervosa)		X
Hairy Honeysuckle (Lonicera hispidula)		X
Western White Anemone (Anemone deltoidea)	X	
Hoary manzanita (Arctostaphylos canescens)	X	
Heart-leaved arnica (Arnica cordifolia)	X	
White-Veined wintergreen (Pyrola picta)	X	

A notable successional characteristic in the "Mixed Conifer - Mixed Evergreen" and "White Fir" zones in the extensive acreage dominated by brushfields of dry-site species (such as manzanita and ceonothus) that have followed repeated fires to the exclusion of conifer reproduction. [38]

(2) Eastern Oregon - Eastern Washington - Rocky Mountain

This region may also be viewed in terms of elevational zones. [39, 40, 41] Four zones are generally found throughout the region. These include: (1) the (usually) lowermost "Ponderosa Pine Zone"; (2) the mid-elevational Douglas-fir Zone; (3) the higher elevational "Englemann Spruce and/or Subalpine Fir Zone"; and (4) Timberline. Other zones are also present on a more localized basis such as (1) "Grand Fir" in eastern Oregon, eastern Washington and northern Idaho; (2) "Western Hemlock" in the same area; and (3) "Lodgepole Pine" in south-central Oregon. Daubenmire [42] recognizes additional communities as related to tree species demonstrating reproductive success; these are "Western

Redcedar" and "Mountain Hemlock". Thus throughout this region an important distinction is that zones do not always occur in a single mountain, nor do they always occur in sequential belts.

Major tree species found within the region and their occurrence within the major zones are shown on Table V and are estimated as follows: 1 = abundant, 2 = common, 3 = uncommon, 4 = rare or absent.

TABLE V

MONTANE SUB-BIOME

SPECIES OCCURRENCE BY ZONE

E. Oregon - E. Washington - Rocky Mountain Region

Species	ZONES					
	* Pond. Pine	* Doug. Fir	Grand* White Fir	* West. Hem.	* Eng.Sp. Sub.Fir.	Timber-line
Western White Pine (Pinus monticola)	4n	4n	3n	1n	3n	4n
Whitebark Pine (Pinus albicaulis)	4n	4n	4n	4n	2n	1n
Lodgepole Pine (Pinus contorta)	2	2	2	2	2	3
Ponderosa Pine (Pinus ponderosa)	1	2	2	4	4	4
Western Larch (Larix occidentalis)	4n	2n	2n	4n	3n	3n
Engelmann Spruce (Picea engelmanii)	4	4	4	3	1	2
Blue Spruce (Picea pungens)	4	3	4	4	2	2
Western Hemlock (Tsuga heterophylla)	4	3	4	1	4	4
Mountain Hemlock (Tsuga mertensiana)	4	4	4	4	2	2
Douglas-fir (Pseudotsuga menziesii)	2	1	2	2	4	4
Grand Fir (Abies grandis)	3n	2n	1n	3n	4n	4n
White Fir (Abies concolor)	3s	2s	1s	3s	4s	4s
Subalpine Fir (Abies lasiocarpa)	4	4	4	4	2	2
Western Redcedar (Thuja plicata)	4	3	3	2	4	4

* zones containing significant amounts of BLM acreage.

n = northern portion of region only

s = southern portion of region only

In the "Ponderosa Pine Zone", the importance of fire in shaping the vegetation is heavily stressed. [43] Generally speaking, older ponderosa pines are more fire resistant than associated trees, hence this species has dominated in the past. Burning also may substantially reduce shrub cover and favor increased grass cover, especially on dryer sites.

Relatively "cool-moist" and "warm-dry" sites can also be identified by plant communities throughout the Ponderosa Pine Zone in Oregon, Washington, and northern Idaho. [44. 45] Species usually found in forest stands on these sites include:

TABLE VI

Species (X = Presence)	SITE	
	Cool-Moist	Warm-Dry
TREES		
Douglas-fir (Pseudotsuga menziesii)	X	
Grand Fir (Abies grandis)	X	
Western Juniper (Juniperus occidentalis)		X
Oaks (Quercus)		X
SHRUBS & HERBS		
Common snowberry (Symphoricarpus albus)	X	
Mallow ninebark (Physocarpus malvaceus)	X	
Idaho fescue (Festuca idahoensis)		X
Bluebunch wheatgrass (Agropyron spicatum)		X
Needle & Thread (Stipa comata)		X
Bitterbrush (Purshia tridentata)		X

Blue wildrye (Elymus glaucus)		X
Elk sedge (Carex geyeri)	X	
Mountain mahogany (Cercocarpus)	X	
Wheeler bluegrass (Poa nervosa)	X	
Strawberry (Fragaria)	X	
Fireweed (Epilobium angustifolium)	X	
Hawkweed (Hieracium)		X

2. Aquatic Vegetation

Aquatic plants are a vital component of all aquatic ecosystems, and since they are relatively common to all three sub-biomes, will be described on the basis of the Coniferous Forest Biome.

Aquatic plants provide food and cover for insects, fish and other invertebrates as well as waterfowl, fur bearers, certain big game species during some seasons, and non-game birds and animals. A healthy growth of aquatic vegetation along stream banks and lake shores prevents soil erosion, gives additional protection to stream channels during extreme floods, and adds to the natural beauty of the biome. Some type of vegetation grows in nearly all waters of the biome, depending upon water depth and movement, available nutrients, suitable temperature, salinity, light for photosynthesis, and time for growth to take place.

The aquatic environment is often classified as either running or standing water habitat. The running water habitat includes watersheds from the smallest mountain stream at high elevations to major rivers in valleys at relatively low elevations. Running water thus passes through the Coniferous Forest Biome and eventually enters the oceans. Streams at higher elevations generally contain less aquatic vegetation than those at lower elevations due to cooler water, steeper gradients, and a lower concentration of nutrients.

Standing water habitats of lakes, reservoirs, ponds, marshes, and bogs are all found in the biome. A greater variety and more profuse

growth of aquatic plants usually occurs in standing than in running water habitats. Marshes and ponds are shallow - water habitats. Lakes are generally classified into three major groups according to their geologic age: young, mature and old, having the following characteristics of productivity and aquatic vegetation. [46]

- Young. Geologically young, less productive lakes, deep with narrow shoals or none, clear water of blue to green color, low in nitrogen and phosphorous, low in phytoplankton (both macroscopic and microscopic plants, including algae), and few littoral plants (macrophytes or higher, vascular plants).
- Mature. Geologically more mature and productive lakes, usually shallow with broad shoals, color green to yellow and brownish green with low transparency, rich in nitrogen and phosphorous, rich in phytoplankton with dense blooms, and littoral plants abundant.
- Old. Lakes in bog surroundings or in geologically old land areas, acidic waters yellow to brown with low transparency, low in nitrogen and phosphorous, phytoplankton low with rare blooms, few littoral plants, but rich in humic materials.

Most young lakes are found at higher elevations throughout the Coniferous Forest Biome, whereas mature lakes occur at all elevations. Mature lakes, ponds and marshes (both marine, and freshwater, including estuaries) are areas of enormous biological productivity because of the rich waters and abundant communities of aquatic vegetation.

Aquatic plants are usually grouped into three general categories: free-floating, submersed, and emersed. Representative plant species of each group common to all parts of the Coniferous Forest Biome are listed as follows: [47, 48, 49, 50]

- Free-floating. Green and blue-green algae; duckweed (Lemna).
- Submersed. Stonewort or muskgrass (Chara); bladderwort (Utricularia) sometimes emersed; pondweed (Potamogeton); water milfoil (Myriophyllum); and mare's tail (Hippuris).
- Emersed. Floating pondweed (Potamogeton); water shield (Brasenia); pond lily (Nuphar); cat-tail (Typha); bulrush (Scirpus); bur-reed (Sparganium); buttercup (Ranunculus); sedge (Carex); marsh yellow cress (Rorippa); horsetail (Equisetum); spike-rush (Eleocharis); mannagrass (Glyceria); slough grass (Beckmannia); reed canary-grass (Phalaris); cotton-grass (Eriophorum); peat moss (Sphagnum); arrow-grass (Triglochin); and willow (Salix).

Aquatic plants tend to grow in communities depending on water depth, which appears to be the major habitat requirement on most species. In aquatic ecosystems some plants occur in open water, others occupy the littoral zone, (shallow area occupied by vascular plants) and different species grow along the shores of lakes and banks of rivers.

Plant communities are readily apparent in a typical standing water environment. Algae occurs in deep, open water. Duckweed is also found floating in deep water but occurs at all water depths. Rooted

vegetation is restricted to the littoral zone where light penetrates. Here dense beds of submersed plants (water milfoil, pondweeds, muskgrass) occur. As water depth decreases in inshore areas, submersed species give way to emersed plants like floating pondweed, pond lily, cat-tail, and bulrush. Vegetation dominating the shallowest water and shoreline includes mannagrass, buttercup, water cress, bur-reed, sedge, and willow.

Plant communities in standing water environments are constantly changing due to natural processes and eutrophication (natural enrichment). Shoal areas are first developed by sedimentation from shore erosion and tributary streams. Rooted vegetation grows on the shoals and contributes to filling of lakes by retaining debris and sediment. Tributary streams continue to add more nutrients. Dense growth of emergent plants and mats of sphagnum moss extend outward from shore. Dead plant material accumulates and further fills the lake. Succession of grasses and sedges then converts the lake into marshes or bogs, and finally dry land. Plant succession is therefore an important factor in the gradual conversion of water bodies to land.

Some aquatic species are adaptable to wide variations in environment. The same species are often found in widely diverse situations of water temperatures, quality, and velocity. [51] They can often survive adverse growing conditions. Examples of cosmopolitan species found throughout parts of the Coniferous Forest Biome were previously listed by genera. Other species are restricted in distribution to more specific conditions; e.g., eel grass (Zostera marina) is an important marine species

found along rocky ocean shores and in estuaries bordering the Northwest Coastal Forest. The distribution of many other species is dependent upon altitude and associated climatic differences. The coastal stellate sedge (Carex phyllomanica) grows in coastal marshes of the Northwest Coastal Forest, whereas the Carter Lake sedge (C. campylocarpa) occurs in alpine and subalpine aquatic habitats of Oregon and Washington.

I. Animals

1. Wildlife - Terrestrial

A wide variety of terrestrial animals are found in the Coniferous Forest Biome. Under pristine conditions, the three basic requirements of food, water and cover is usually well met for most species. This Biome produces a conifer overstory from timberline to the ocean, and from above the Arctic Circle to near the Mexican border. Some adaptable species are found throughout the Biome. Others are much more specific in their requirements. In general, the Coniferous Forest Biome is characterized by the following terrestrial wildlife families.

- Mammals. Deer (Cervidae), bears (Ursidae), wolves, coyotes and foxes (Canidae), Squirrels (Sciuridae), wildcats-cougar (Felidae), weasels (Mustilidae).
- Birds. Hawks, both (Accipitrinae and Buteoninae), eagles (Buteoninae), owls (Tytonidae and Strgidae), grouse (Tetraonidae), woodpeckers (Picidae), finches and sparrows (Fringillidae).
- Reptiles and Amphibians. True toads (Bufonidae), true frogs (Ranidae), garter snakes (Colubridae).

Wildlife typical of the Biome are generally adapted to a closed canopy of coniferous timber interspersed with small openings. Some species, such as the herbivors, respond to an edge effect created by forest meadows, logging or fires that allow development of a nutritious understory of vegetation. Other species, including the raptors and larger predators, may respond adversely to loss of the timber overstory, especially

if it is accompanied by human activity.

and northern spotted owls depend on tree dwelling mammals for their prey, such as the red-backed mouse, red and flying squirrels, and the small birds that are found in forested areas. Bald eagles and ospreys need dead and dying trees adjacent to lakes, streams and the ocean for nest sites since their prey is principally fish.

Many fur-bearers and birds in this Biome are adapted to a semi-aquatic habitat, and the presence of streams, lakes and ponds add greatly to the variety of wildlife. In a so-called "virgin forest" this is usually not a limiting factor. Most forest wildlife can adapt to certain habitat changes, but extensive management activities can be greatly detrimental to many species, especially when accompanied by vehicles and people.

The following rare or endangered wildlife species are found in the Coniferous Forest Biome:

- Northern Rocky Mtn. wolf (Canis occidentalis)
- Glacier bear (Euartos emmonsii)
- Grizzly bear (Ursus, sp.)
- Columbian whitetailed deer (Odocoileus virginianus leucurus)
- California bighorn (Ovis canadensis californiana)
- American peregrine falcon (Falco peregrinus anatum)
- Arctic peregrine falcon (Falco peregrinus tundrius)
- Red cocaded woodpecker (Pendragopus borealis)

- Wallowa grey-crowned rosy finch (Leucosticite tephrocotis)
- Shasta salamander (Hydromantes shastae)

a. The Northwest Coastal Forest

This sub-biome supports wildlife habitat where water is usually not a severe limiting factor; humidity is high and the temperature range is narrow. There is usually a deep layer of duff and organic soil rich in micro-organisms. The huge trees produce dense shade resulting in a poorly developed understory. The principal wildlife are generally related to Rocky Mountain species.

- Mammals. Roosevelt elk (Cervus canadensis roosevelti), black-tailed deer (Odocoileus hemionus columbianus), black bear (Euarctos americanus), bobcat (Lynx rufus), lynx (Lynx canadensus), cougar (Felis concolor), coyote (Canis latrans), Mtn. beaver (Sewellel) (Aplodontia rufa), white-footed deer mouse (Peromyscus maniculatus), snowshoe hare (Lepus americanus), Douglas chickadee (Sciurus douglasii), mink (Mustela vison).
- Birds. Pacific horned owl (Bubo virginianus pacificus), northern spotted owl (Strix occidentalis caurina), Cooper's hawk (Accipter cooperi), bald eagle (Haliaeetus leucocephalus), sooty grouse (Dendragapus fuliginosus), winter wren (Nannus hiemalis pacificus), band-tailed pigeon (Columba fasiata fasciata).
- Amphibians and Reptiles. Pacific giant salamander (Dicumptodon ensatus), Puget Sound garter snake (Thamnophis sirtalis).

Other wildlife are found in more specific vegetative zonal types: the hemlock looper (Ellopia fascellaria lugubrosa) and the Sitka spruce beetle (Dendroctonus obesus) are serious defoliations found in the Sitka spruce zone.

In the western hemlock (or coastal Douglas-fir) zone, the little Trowbridge's shrew (Sorex trowbridgii t.), an insectivore, also feeds on Douglas-fir seed. The Douglas-fir bark beetle (Dendroctonus pseudotsugae) is also found.

The fisher (Martes pennanti pacifica) and the rare flammulated owl, (Otus flammeolus) are found in the silver fir and hemlock zones below timberline.

Above timberline the alpine zone is typified by the wolverine (Gulo luscus), and further north, the white crowned sparrow (Zenotrichia leucophrys).

Most of the general habitat requirements previously mentioned pertain to this sub-biome. This sub-biome has the ability to rapidly produce desirable habitat following fires, logging, and other disturbances to the overstory than Taiga and Montane forests. This is due to site, soils, moisture, and elevations. Water is not usually a limiting factor.

Deer and elk generally follow any natural or man-made opening of the dense overstory, such as caused by fires or logging, to take advantage of resulting nutritious ground vegetation.

The cougar, black bear, northern lynx, and Alaskan grizzly bear inhabiting this sub-biome are wilderness species that need the seclusion and escape cover afforded by dense forests.

Many of the small mammals and birds, and emphibians found in coastal forests depend on the variety of insect life that abounds in the damp, mild environment, as well as the great mass of nutritious seeds produced by evergreen trees.

Mink, marten, otter, beaver and muskrat about in this habitat due to the proximity of lakes and streams that afford food, bank dens, and travel routes. While waterfowl are not normally considered as representative birds of timbered habitat, many ducks use the lakes, rivers and estuaries adjacent to the moisture-holding forest lands. Some ducks, including the golden-eye, bufflehead, and wood duck, nest in tree cavities immediately adjacent to water.

b. Montane Coniferous Forest

A much greater variety of habitat exists in this sub-biome than in the coastal forest or taiga, due to the variety of vegetative types. This allows a high degree of use by adaptable wildlife. Some 56 species of breeding birds have been recorded in the central Rocky Mountains. Representative wildlife includes:

- Mammals. Rocky mountain elk (Cervus canadensis nelsoni), mule deer (Odocoileus hemionus hemionus), mountain goat (Oreamnos americanus), Rocky Mtn. bighorn (Ovis canadensis canadensis), cougar (Felis concolor), black bear (Euarctos americanus), fisher (Martes pennanti), pika (Ochotona princeps), Rocky Mtn. cottontail (Sylvilagus nuttallis).

- Birds. Golden eagle (Aquila chrysaetos canadensis), screech owl (Otus asio), grey-crowned rosy finch (Leucosticte tephrocotis), three-toed woodpecker (Picoides tridactylus), white-tailed ptarmigan (Lagapus leucurus), American magpie (Pica mittalli), Clark's nutcracker (Nucifraga columbiana).
- Amphibians and Reptiles. Pacific tree frog (Hyla wrighorum), California mountain kingsnake (Lampropelis zonata).

As with the coastal forest sub-biome, many other wildlife species are found by regions of the biome.

The southwestern Oregon-northern California area has such typical species as the ringtailed cat or cacomistle (Bassariscus astutus oregonus) found along the lower areas of the "mixed conifer-mixed evergreen" zone. The Douglas ground squirrel (Otospermophilis grammurus douglasii) is common in the mixed forests of this area. The California, or acorn woodpecker (Balanosphyra formicivora) also represents this area, and the Northern Pacific rattlesnake (Crotalis viridis) is present in the transition zone area. Destructive beetles, such as the bark beetle (Ips emarginatus) infest ponderosa pine. This zone may have heavy blacktailed deer concentrations rather than mule deer populations.

The eastern Oregon - Washington and northern Rockies portion of the Montane forest may be represented by the Cascade hoary marmot (Marmota caligata canadensis), and mountain caribou (Rangifer montanus), moose (Alces americana shirasi), grizzly bear (Ursus horribilis), American pipit (Anthus spinoletta), and the boreal toad (Bufo boreas).

In the central and southern Rockies, the Kaibab squirrel (Sciurus kaibabensis) and the tawny deer mouse (Peromyscus maniculatus rufinus) are important species.

Water can be a limiting factor in the Oregon habitat requirements of this sub-biome. The diversity of habitat and climatic conditions produces a diversity of wildlife. Woodpeckers make extensive use of the oaks and other hardwoods found in parts of this sub-biome for food, food storage and nesting. Many other birds and small animals also use cavities in dead and dying trees as nest and den sites. The many herbivores inhabiting this sub-biome utilize most of the upper areas as summer range. Deep snows and cold preclude year-round residency, especially for deer and elk. These ruminants seek suitable winter range within reasonable migration distance for survival. High mountain meadows, and vegetation above timberline is typical sheep and goat year-round habitat.

As noted for other timbered areas, the larger predators -- wolverine, wolves and grizzly bears, and cougar -- require the privacy of wilderness to survive.

The open forests in the southern part of this sub-biome merge into the Upper Sonoran zones of California and the southern Rockies. These warm, dry, fairly open timbered stands are inhabited by the birds, animals and reptiles using drier sites; they are typified by the Kaibab squirrel, ringtailed cat, rattlesnake, lizards, and pinon jay.

c. Taiga Coniferous Forest

Most of the animals in the Taiga Forests are shy and retiring. They can tolerate cold winters with much snow. The herbivores are largely browsers. Some, such as the moose, snowshoe hare, and grouse, depend (at least in part) on broad-leaved plant communities found in burns or natural openings, and along streams.

The Taiga has an enormously important seasonal cycle conspicuous in the dormancy of its invertebrates and of many vertegrates, and in the spring influx and autumn departure of migratory birds. Outbreaks of certain insects, particularly bark beetles and defoliators, result in destruction of large areas of forest. About fifty species of insects are important. The spruce budworm and the tent caterpillar are dominants and important everywhere.

Animals commonly found in the Taiga include:

- Mammals. Wolverine (Gulo luscus), lynx (Lynx canadensis mollipilosus), snowshoe rabbit (Lepus americanus macfarlani), red squirrel (Sciurus hudsonicus petulans), Artic caribou (Rangifer torandus granti), moose (Alces gigas), Alaska porcupine (Erithizon epixanthum myops), Alaska least weasel (Mustela rixosa eskimo), Northern flying squirrel (Glaucomys sabrinus yukonensis), Alaska marten (Martes americana actuosa), hoary bat (nycteris cinera).

The moose, Dall sheep, and mountain caribou are found principally in the timbered mountains in the southern part of this sub-biome.

- Birds. Gyrfalcon (Falco rusticolus obsoletus), snowy owl (Nyctea nyctea), Arctic horned owl (Bubo virginianus subarcticus), spruce grouse (Canachites canadensis), ptarmigan (Lagopus leucurus), Arctic three-toed woodpecker (Picoides arcticus).
- Reptiles and Amphibians. True frog (Rana sylvatica).

As far as habitat requirements are concerned, the timberlands of the Taiga, although generally sparse, do provide necessary winter shelter as well as food for browsing herbivores, the ruffled grouse, and other birds and animals. The adaptable barren ground caribou can dig through two feet of snow and reach the desirable reindeer mosses, sedges, and lichens if browse species are not available.

Predator-prey relationships are definite, with larger predators, such as the lynx and great horned owl populations, dependent principally upon the presence of the varying hare, that is in turn dependent on low shrubs.

2. Wildlife - Aquatic

The aquatic animal communities in the Coniferous Forest Biome of the western United States are of rather specific diversity and species. The biome is generally characterized by high quality, near neutral water, and low water temperature with fair numbers of aquatic organisms in the streams and rivers. Lower elevation lakes and reservoirs become more productive if constant flushing is not a factor in loss of nutrients. The waters generally start at high elevations, especially in the Montane Sub-biome. The large rivers formed from

tributary streams may have significant changes in water quality, especially temperature at low runoff stages. The differences in temperature and water quality from higher to lower elevations provide subtle changes in the aquatic ecosystems. In general, the Coniferous Forest Biome is characterized by some of the following typical aquatic animals.

- Fish. Trout, salmon and whitefishes - Salmonidae
- Invertebrates. Freshwater clams and mussels - Pelecypoda
  Freshwater shrimps and crayfish - Decapoda
  Mayflies, stoneflies, caddis - Insecta

The following endangered fish are found in the Coniferous Forest Biome:

Westslope cutthroat trout - Salmo clarki (Montana)

Arctic grayling - Thymallus arcticus (Montana)

Colorado cutthroat trout - Salmo clarki (Colorado)

Greenback cutthroat trout - Salmo clarki stomias (Colorado)

Little Kern golden trout - Salmo aguabonita (California)

Olympic mudminnow - Novumbra hubbsi

The aquatic animals typical of the Biome are adapted generally to habitat conditions of the highest quality of food, water and cover. General minimum water quality standards set by state and federal regulations may not be adequate for protection of these organisms. In many states, specific regulations are designed for waters in these higher watersheds.

The animals have adapted to stream habitat that is generally of coarse material free of fine clays, sand and silt. Organisms that have adapted to slow moving and silt laden rivers are generally absent in Coniferous Forest waters. Some animals may be found in the transition areas, but are on the fringe of their normal habitat.

Water requirements considered optimum for complete life histories of aquatic animals in the Biome are as follows:

Dissolved oxygen	-	7 - 9 ppm
Hydrogen Ion (pH)	-	6.8 - 7.8 ppm
Total dissolved solids	-	150 ppm
Jackson Turbidity Units	-	5 or less
Water temperature	-	50° - 60° F

The larger animals, like fish, can withstand more extremes in changes of water quality than organisms such as aquatic insects and crustaceans.

Aquatic insects, phytoplankton and crustaceans have adapted to larger substrate such as rocks and gravel. Streams have generally stabilized in heavy forested areas and contain optimum amounts of riffle and pool areas. Most streams develop the aquatic organisms in the faster moving riffle-gravel-rubble areas.

Fish have adapted to high water quality, low water temperatures and stabilized streambanks. Vegetation along the streams is extremely important in keeping the protective cover and shading of the stream intact. For reproduction, salmonid fish need gravel of a size range from

1/2 to 5 inches in diameter for deposition of eggs during spawning and rearing of the ova. Optimum size of the gravel depends on the species of fish. Good, clean, silt free gravel is an important habitat requirement in the aquatic ecosystem of the Coniferous Forest Biome.

a. Northwest Coastal Coniferous Forest

The Northwest Coastal sub-biome supports a major portion of the sport and an internationally exploited commercial anadromous salmon populations. All five species of Pacific salmon are found in these waters.

Chinook salmon - Oncorhynchus tshawytscha

Sockeye salmon - Oncorhynchus nerka

Coho salmon - Oncorhynchus kisutch

Chum salmon - Oncorhynchus keta

Pink salmon - Oncorhynchus gorbuscha

Several indigenous trout characterize the sub-biome. These fish provide a sport fishery of high annual importance in all Pacific Coast states and Canada.

Rainbow trout (steelhead) - Salmo gairdneri

Coastal cutthroat trout - Salmo clarki clarki

Dolly Varden trout - Salvelinus malma

Miscellaneous indigenous fish typical to the sub-biome include species such as the following:

Whitefish - Prosopium williamsoni

Squawfish - Ptychocheilus oregonensis

Red-sided shiner - Richardsonius balteatus balteatus

Coarse-scaled sucker - Catastomus macrocheilus

Pacific lamprey - Entosphenus tridentatus

Sculpins - Cottidae

The Northwest Forest sub-biome also surrounds hundreds of important estuaries on the Pacific Coast where freshwater from the forest drainages meet and intermix with the salt water of the ocean. The estuaries support a variety of marine species and juvenile life stages of anadromous fish. Typical examples, in addition to the Pacific salmon, are:

Seaperches - Embiotocidae

Flounders - Pleuronectidae

Eulachon (smelt) - Thaleichthys pacificus

Dungeness crab - Cancer magister

Cockle clam - Clinocardium nuttalli

Washington clam - Saxidomus giganteus

Habitat requirements of aquatic organisms are generally the same as stated for the entire Coniferous Biome. It is emphasized that the special requirements for anadromous fish are especially important in the Northwest Coastal area. Adult fish migrating from the ocean through the estuaries and to the gravel spawning grounds need special consideration. During the migration period the fish may be able to pass through waters of high turbidity, but must have water of good quality on the spawning grounds. Routes of access to the spawning grounds must not be blocked

by obsturctions such as dams, culverts, or debris. The ova, after deposition in the gravel, require high quality water and freedom from disturbance for periods as high as three or four months. Fry and fingerling need quality water, cover and food during their freshwater life before migration to the sea. Freshwater life of the small fish varies from a few months to several years depending on the species.

b. Taiga Coniferous Forest

The Taiga Forest sub-biome provides an aquatic ecosystem characterized by high quality water, low water temperatures, alpine lakes, ponds and bogs in various stages of life. The larger river systems contain commercially important populations of anadromous pacific salmon.

The Alaska Bristol Bay sockeye fishery is of international importance and one of the largest migratory animal populations in the world.

Sockeye and chum salmon are the most numerous. Other typical fish to the Taiga Forest are as follows:

Arctic grayling - Thymallus arcticus

Whitefish - Coregonus sp.

Inconnu (sheefish) - Stenodus leucichthys

Lake trout - Salvelinus namaycush

The freshwater environment in the Taiga is generally low in aquatic organisms. The reduced food supply combined with lower water temperatures provide a habitat contributing to the slow freshwater growth

rate of fish. The high quality water, however, provides a medium for good hatching and rearing of anadromous species of fish. Rapid growth is obtained after the fish move into the productive estuaries and oceans.

A variety of planktonic animal forms provide most of the food in lakes for species such as sockeye salmon. Other invertebrates important in these waters are aquatic insects such as mayflies, stoneflies, caddis and various diptera.

In addition to the habitat requirements stated in the other sub-biomes conditions in the Taiga are generally of a pristine nature. Many of the larger river systems are of glacial origin and constantly turbid from silt. These rivers are routes of access for anadromous fish to the clear, high quality spawning and rearing tributaries. The character of most of the important fish producing streams is preserved by the thin riparian stand of white spruce forest.

c. Montane Coniferous Forest

Migratory and anadromous species of fish are normally absent except in some areas of northern California and southern Oregon. The forested area waters are characterized by salmonid species of fish such as trout and whitefish. Transition areas occur within the fringes of the Montane Forest because of changes in water quality, such as higher temperatures and turbidities. In these areas are found, along with reduced salmonid populations, several species of cyprinids, such as squawfish, chubs and suckers.

The high quality waters support freshwater clams and mussels, and good populations of crustaceans and aquatic insects.

Typical fish in the Montane Forest sub-biome are as follows:

Cutthroat trout - Salmo clarki sp.

Rainbow trout - Salmo gairdneri

Whitefish - Coregonus and Prosopium

Introduced trout have also become established and are now typical of the area.

Brook trout - Salvelinus fontinalis

Brown trout - Salmo trutta

Lake trout - Salvelinus namaycush

Other endemic fish distinctive to the sub-biome are:

Dace - Rhinichthys sp.

Suckers - Catostomidae

Probably the most important habitat requirement is silt-free water with temperatures of less than 70°. Diversions of water for irrigation and a variety of consumptive uses are now impacting the aquatic habitat in this Biome. Consistent water temperatures of over 70°F during summer months invite a reduction of salmonid fish and an increase in warm water species. A variety of land management abuses may increase the amount of silt in streams and lead to changes in aquatic fauna. High riparian vegetation along streams is important in holding water temperatures below 70°F for protection of salmonid fish.

3. Domestic Livestock

Grazing by livestock occurs throughout the Coniferous Forest Biome, with the exception of the Taiga, in the more open areas and sparse

timbered stands where water and desirable forage species are present. Cattle, sheep and a few horses graze these areas as part of established livestock operations. In addition, some relatively minor grazing use is made in connection with recreational activities. Most livestock use occurs between April 1 and October 31.

Domestic livestock utilize a wide variety of plant species in the Northwest Coastal and Montane Coniferous Forests. Some of the more common are: Blue wild-rye (Elymus glaucus), Kentucky bluegrass (Poa pratensis), tufted hairgrass (Deschampsia caespitosa) and Mountain brome-grass (Bromus marginatus). The diet of domestic grazing animals consists primarily of grass and forb species in the spring and early summer months. As the season progresses these plants mature and lose their high protein content. Grazing use then shifts more to browse species which maintain a higher protein content during the late summer and fall.

J. Micro and Macro-organisms

1. Soil Organisms

Throughout the Coniferous Forest Biome minute forms of plant and animal life spend their lives at or below the forest floor and are essential to the existence of plants and larger animals. They are a vital part of the cyclic pattern of matter in nature and are the tools with which nature fashions soil from lifeless geologic matrix and plant and animal residue. [69]

Each year most forest floors (with the probable exception of the Taiga) collect an average of two tons of plant and animal debris per acre. [70] This residue becomes the source of life for minute soil flora and fauna which feed upon and gradually decompose the debris. The decomposition releases back to the energy cycle the inorganic compounds necessary for the manufacture of new organic matter.

Numerically, microscopic forms such as bacteria, fungi, and certain molds and algae, predominate. Microscopic protozoa are the most abundant animals. Other tiny animals such as mites and springtails, barely visible to the naked eye, may number 200 million per acre. Many of these minute plants and animals occur world wide, in arctic tundra as well as temperate and tropical forests.

Of the variety and abundance of micro-organisms occurring in forest soils, bacteria, fungi, and actinomycetes are of critical importance in the biochemical energy flow.

Although many types of bacteria are normally present, their collective importance stems from their ability to decompose organic remains and increase the availability of nutrients through oxidation, evolution of carbon dioxide, and symbiotic association with the roots of trees and lesser vegetation. Fixation of atmospheric nitrogen into compounds available to the forest vegetation is accomplished largely by bacteria. [71]

Fungi and fungus mycelia have a part in the decomposition of virtually every leaf or needle that falls to the forest floor. They decompose proteins, cellulose, carbohydrates and lignins. Certain parasitic fungi invade living root tissues causing the eventual desctruction of the plant. Other fungi develop symbiotic associations with the roots of trees and higher plants, permitting mutually beneficial exchange of carbohydrates, nutriets, and other growth-promoting substances. [72]

Actinomycetes exhibit characteristics of both fungi and bacteria. Their importance is associated with their ability to produce antibiotics of high toxicity to certain pathogenic organisms. Certain actinomycetes form symbiotic unions with alder roots, permitting fixation of atmospheric nitrogen. [73]

Other important forest soil organisms are nematodes, rotifers, ticks, larvae, millipeds, centipedes, ants, beatles, spiders, and worms.

Although most of the foregoing soil organisms occur throughout the Montane and Northwest Coastal Coniferous Forests, their presence in the Taiga may be less abundant and restricted to the smaller forms.

2. Aquatic Organisms

Minute organisms that live at the surface, within and on the bottom of streams, lakes and estuaries form significant links in the energy flow of the aquatic ecosystem. While there are some variations in species make-up between sub-biomes they are described on the basis of the Coniferous Forest Biome.

Aquatic organisms fall into three basic blasses, (1) autotrophic (self-nourishing) or producer organisms, chiefly tiny plants, (2) heterotrophic (other-nourishing) consumer organisms, chiefly animals, and (3) a second category of heterotrophics known as reducers, mostly bacteria and fungi.

- Autotrophic (producer). Green plants assimilate inorganic nutrient minerals - usually by photosynthesis - into living organic substances. The largest group of energy producers are tiny algaes, diatoms, and flagellates. Collectively they are at the bottom of the food chain. Those that are found floating free are known as phytoplankton.
- Heterotrophic (consumer). Animal organisms feed upon and digest plant and other animal organic matter, releasing energy in the process. They occupy the next level upward in the food chain and are known as zooplankton. Included are microscopic protozoa and rotifers and larger animals such as sponges, snails, worms and daphnia.

- Heterotrophic (reducers). Bacteria and fungi that decompose more complex organic remains, returning the inorganic minerals for reuse at the start of the energy cycle, releasing the remaining chemical energy in the process.

Stability of the aquatic ecosystem depends upon the degree of equilibrium achieved between the autotrophic and hetertrophic sectors. [74]

K. Human Settlement and Land Use

1. Montane Coniferous Forest

The history of white man's early settlement of the Montane Coniferous sub-biome began with the search for gold and silver, fur bearing animals and exploration of newly acquired territory.

Although some early settlement had taken place in the Southwest on Spanish land grants, it was only after the West became United States Territory, in 1846 and 1848, that the cross-country movement of pioneers gained momentum and the economic development of the West began.

Landform was the primary determinant of early settlement patterns. After crossing mountain saddles, the pioneers usually followed the rivers and valleys and spread out in the basins and plains. They preferred river banks and adjacent uplands for settlement. The rivers provided transportation and the trees growing nearby provided wood for home construction and fuel.

Settlement gained momentum when the vanguard of settlers reached the plains. Settlement and development of the public domain was further facilitated through passage of various public land laws. These laws were designed to provide title to tracts of land, varying in size from 160 to 640 acres, upon compliance with occupancy and use conditions.

Settlement, however, was only the initial step in development. Settlers who had located on the land could not remain isolated members of society. They were followed closely by churches and schools. Frontier towns and trading centers sprang up over the country. Travel to the West

was greatly facilitated when, in 1869, the central transcontinental railroad was opened. Soon followed by other trunklines, these railroads pierced the frontier and ran ahead of settlement. [75]

Although settlement and development took place rapidly in the more fertile valleys and plains, the establishment of permanent settlements in the mountainous terrain that comprises the Montane sub-biome took place in a much different fashion. Characterized by steep, rugged topography with shallow, poorly developed soils, the mountains afforded little opportunity for homesteading. Exceptions occurred in sheltered fertile valleys between the ranges.

Mining of gold and silver, and later timber harvesting, were the principal attractions of the western mountains. Although many of the early mining settlements have either disappeared or are ghost towns today, others, more favorably situated, survived. In certain locations, mining still provides significant income and employment. Many rural counties in Colorado, Idaho, Montana, Wyoming, Washington and Oregon which had their greatest population prior to 1920 have since decreased. Large National forests and parks in the area have virtually no permanent year-round habitation. Forest products, mining, agriculture, and tourism are the mainstays of the economy. Lumbering and livestock grazing occur generally throughout the Montane sub-biome.

Livestock grazing of the alpine meadows is normally limited to the summer months, with the animals being moved to lower ranges, outside the sub-biome, during the fall and winter.

Although most of the forest lands within the region are inside National Forests, and are administered by the Forest Service, the BLM administers 1,631,000 acres of commercial forest on the public land within the region, from which $1,808,000 was received from sale of timber in 1971.*[76]

Communities tend to be small, and are oriented to logging, ranching or mining which may occur in the area. A phenomenon that began after World War II and has increased alarmingly in some parts of the region having non-existent or weak local land use controls has been the development of "speculative" homesites. Frequently located in remote rural areas, these recreation sub-divisions more often than not have failed to develop as portrayed in the sales brochures.

Recreation-tourism is growing rapidly in importance throughout the sub-biome. In areas with outstanding resources, such as the Yellowstone Park area, or Aspen, Colorado, tourism is the mainstay for local communities. The Pacific Crest Trail, routed along the crest of the Cascade Mountains, stretching from Canada to Mexico, leads to points of scenic beauty accessible only by pack horse or foot and annually receives increased use. Throughout the Montane region Federal, state, county, and municipal organizations as well as private enterprises have been active in the development of scenic and recreation resources. Hunting, fishing, sightseeing, picnicing and camping, and winter sports are the predominant types of recreation activities.

* Excluded from these figures are the O&C lands administered by the BLM in Jackson and Josephine Counties in Oregon. Although they are within the Montane sub-biome, O&C land data pertaining to them are included with the other O&C Counties under the Coastal sub-biome section.

Although much of the Montane Coniferous Forest lies within the National Forest system, the BLM has developed 117 recreation sites containing more than 2400 camping, picnicing and trailer units on the Bureau administered public lands of the region.* There are additionally over 8000 miles of stream and more than 5 million acres of lakes and reservoirs on these public lands within and adjacent to the Montane sub-biome available for fishing and other water-oriented recreation. [77] Additionally, most of the public land within this sub-biome is open to hunting. Collectively, recreation visits to the Bureau administered public lands within and adjacent to the Montane sub-biome were estimated at more than 37 million during 1971.

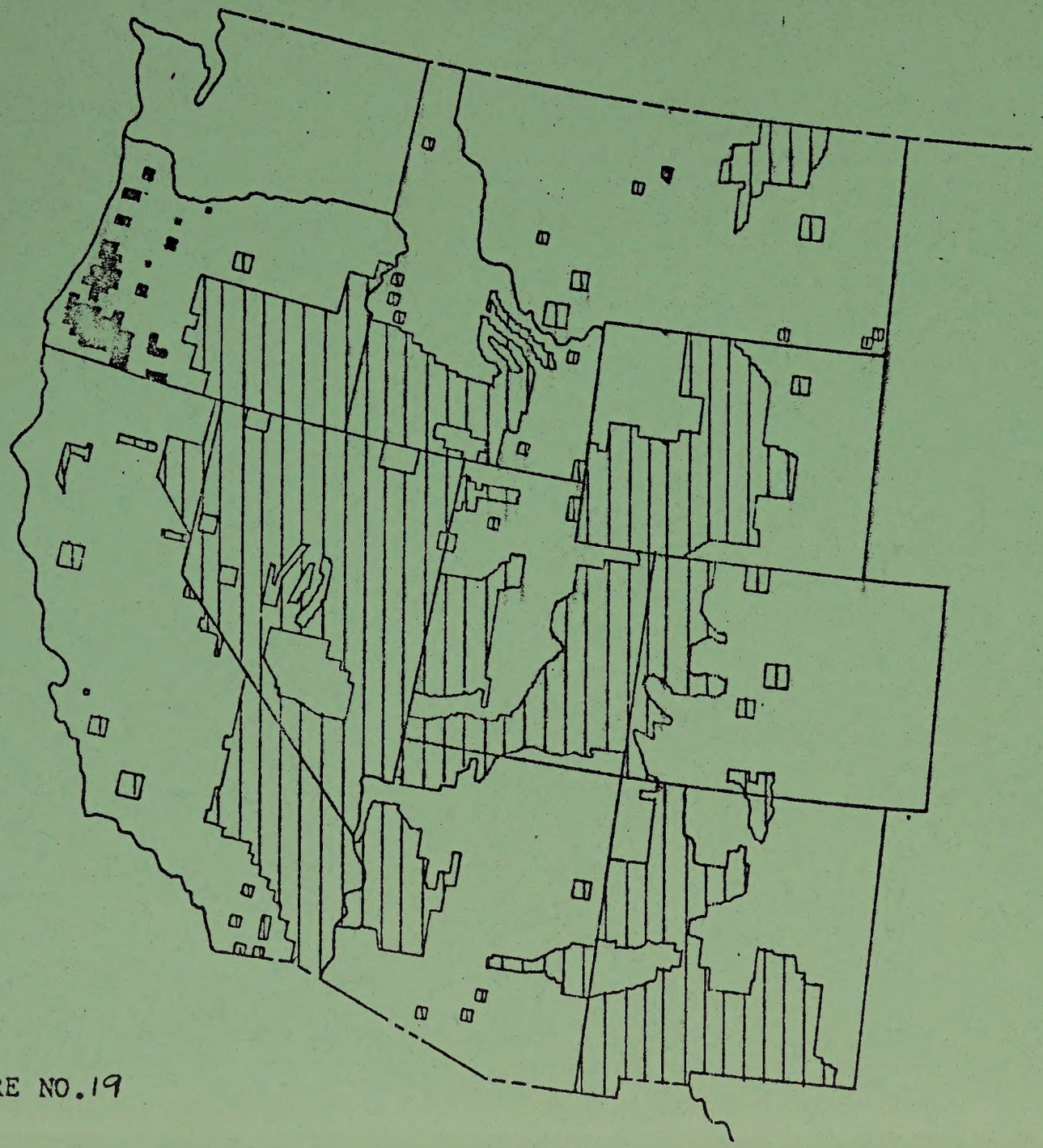
Figures 19 through 20 show land ownership patterns and land use patterns for all three Coniferous Forest sub-biomes.

2. Northwest Coastal Coniferous Forest

The history of early settlement of the Coastal Forest region followed essentially the same pattern as the Montane region to the east. Although rough and mountainous for the most part, the region contains some of the most productive softwood forests in the United States. Often referred to as the Douglas-fir Region for the principal tree species found there (except along the Alaska Coast), other valued softwoods are cedar, hemlock, spruce and true fir.

* Figures are exclusive of the public land states of Nevada, Alaska and Oregon west of the Cascades which are outside the Montane sub-biome. Also not all of these recreation sites occur within the Montane sub-biome, but lie in adjacent biomes.

LAND ADMINISTERED BY THE BUREAU OF LAND MANAGEMENT



LEGEND

O&C Lands (BLM)

Public Domain Lands (BLM)

FIGURE NO.19

ALASKAN LANDS ADMINISTERED BY THE BUREAU OF LANDSMANAGEMENT

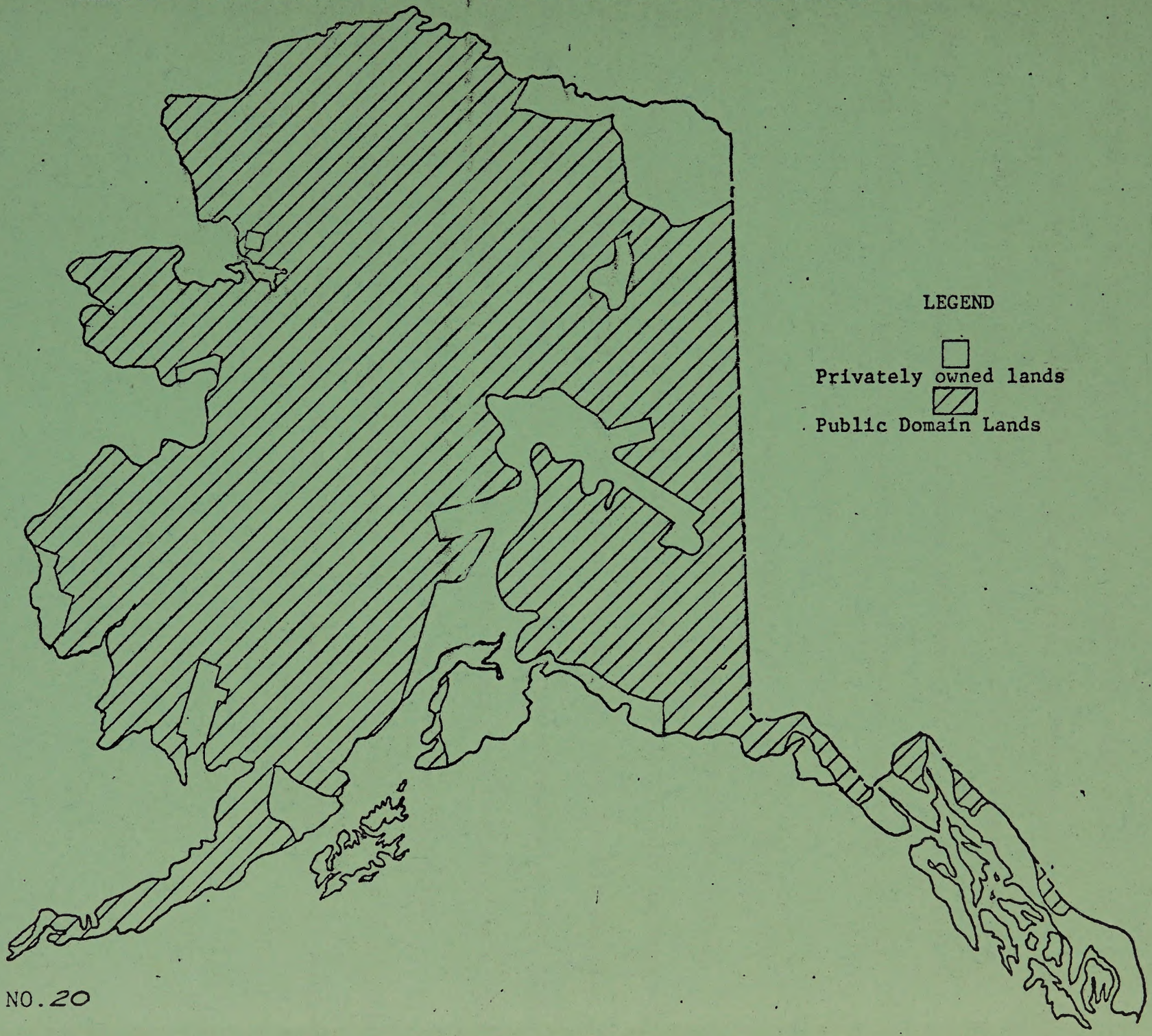


FIGURE NO. 20

The gold rush and subsequent population growth in California afforded the first export market for the region's vast supply of mature timber. This market expanded into the developing Midwest with the extension of intercontinental railroads into the Pacific Northwest in the 1880's and 1890's. Production of wood products for a national market was the single most significant economic factor contributing to the rapid population growth of the region into the 1920's.

Lumbering and wood products industries continue to play an important role in the economy. In 1968 the Pacific Northwest Forest and Range Experiment Station estimated the degree of economic dependency upon timber industries of selected areas within the Douglas-fir Region of Washington, Oregon and California. Dependency was measured as a percent of total economic (or export) base employment attributable to timber dependent industries. The researchers found that timber dependent industries accounted for approximately 45 percent of the region's economic base employment. Table VII shows timber-dependency ratings for 15 economic areas within the region. [79]

TABLE VII

CLASSIFICATION OF ECONOMIC AREAS BY DEGREE OF DEPENDENCY UPON TIMBER-BASED EMPLOYMENT

Dependency	Economic Area*	Percentage of 1960 excess employment dependent on timber-based employment
Slight	Seattle	6.2
	Portland	23.8
	Salem	29.3
Moderate	Bellingham	30.4
	Tacoma	32.5
	Astoria	63.1
High	Medford	70.0
	Corvallis	74.3
	Eugene	76.6
	Longview	81.5
	Aberdeen	88.1
	Eureka	89.6
	Port Angeles	90.5
	Coos Bay	91.6
	Roseburg	99.4

* Economic areas are identified by the names of their respective growth centers.

Note: The authors used the excess-employment technique to determine the portion of employment in an area which was engaged in economic base activities. This approach considers any industry in an area with employment in excess of the national norm for distribution of employment among industries to be producing for export. The percentage of total excess (export) employment (the total may include several industries, basic as well as service, for an area) attributable to timber related industries is computed and defined as the timber-dependency indicator (figures in the right-hand column of Table VII).

The Northwest Coastal sub-biome of western Oregon, Washington and northwestern California contains over 2.5 million acres of commercial forest administered by the Bureau of Land Management. Comprised of both the O&C and public domain, these lands are generally recognized as one of the nation's most productive and valuable commercial forest properties. (See Section I, Part B for a discussion of the O&C lands). During 1971 approximately 1.23 billion board feet of timber worth $52 million were sold from 1.9 million acres of O&C land in Oregon. From this $31.8 million were distributed to the 18 O&C counties under terms of the O&C Act of 1937 and subsequent agreements.* Receipts for Fiscal Year 1972 on a volume of 1.19 billion board feet were $65.5 million of which $37.7 million were distributed to the counties (receipts to the counties include revenues from sale of timber from O&C lands (the largest source), grazing fees, mineral fees, rental and sales of land, and from other sources). [80]

The O&C lands contribute 17.5 percent of the timber harvest in western Oregon. In this same area timber-dependent industries account for 45 percent of the total economic base employment. This dependency ranges from a low of 24 percent in the Portland area to 99 percent in the Roseburg area (Table VII). Thus the O&C lands contribute approximately 8 percent of the total western Oregon economic base employment. [81] The significance of these lands to local and regional economies is further exemplified by the fact that 17 percent (13,500) of the 78,000 persons

* Although Jackson and Josephine Counties are within the Montane Forest sub-biome, for purposes of clarity O&C data from them are lumped with the O&C counties in the Coastal sub-biome.

employed in the lumber and wood products industry in western Oregon in 1965 could attribute their jobs to the O&C timber cut. Payrolls were $89.5 million and the value added to the economy, including the value of the timber cut, was $187.1 million. This compares with the value of total products sold on farms of the 18 counties of $245 million. It is greater than the value added by any other Oregon industry, with the exception of the total lumber and wood products industry. [82]

These jobs in the basic industry in turn generated more than 20,000 other secondary employment jobs (retail, service, and other employees serving the basic employees), and supported a total population of about 80,000 (including the employees and their families). [83]

Further north, along the southeast coast of Alaska, is an additional segment of the Coastal sub-biome, however, it lies within the National Forest.

The Pacific Coast forms the western boundary of the Coastal sub-biome. The proximity to the ocean adds to the recreational diversity of the area. Outdoor activities such as swimming, fishing and camping are some of the more common forms of recreation activity. Digging of clams, both commercially and as a form of recreation, takes place on the beaches and inlets all along the coast, reaching the peak of productivity along the Washington coast and the Puget Sound. Fishing the numerous streams that traverse the coastal strip, many on BLM administered lands including such nationally known ones as the Rogue and Umpqua, yield

exciting fresh-water catches. Saltwater sportfishing has created and supports a growing charter boat industry.

Camping and picnicing is facilitated by the numerous state and Federal parks located along the coast. Further inland, the BLM has developed and administers 59 sites containing over 1200 camping, picnicing and trailer units. [84]

Most of the approximately 3 million acres of BLM administered land in the Coastal sub-biome is available to the public for hunting. Since much of the area is covered by a dense forest, most of the hunting is concentrated in natural or man-made openings such as roads, timber harvest sites or cleared utility rights-of-way. Livestock grazing also occurs in localized areas on the lower, more open sites administered by the Bureau.

The cities of Seattle and Portland are the two principal metropolitan centers in the Coastal sub-biome. The harbor facilities on Puget Sound make the neighboring cities of Seattle and Tacoma major centers of trade with foreign countries and a gateway to Alaska. Supported by the rich agricultural land around it, large accessible timber resources, and a more recent aero-space industry, the Seattle-Tacoma area has had a continuous development since the transcontinental rail lines made it a Pacific terminal.

Further south, at the confluence of the Columbia and Willamette Rivers, the City of Portland is an important trading center. Agricultural products from the rich Willamette Valley flow into and through the city,

while the Columbia Gorge provides easy access by rail, interstate highway and water to the Columbia Basin and Snake River Valley to the east. The flow of materials to and from foreign ports passing over the Portland docks mark the city as one of the major Pacific Coast ports. [85] Further south, on the coast, the deep water port of Coos Bay is developing into a major shipping point.

Low cost hydroelectric power, deep water ports, and availability of labor have encouraged industrial growth of the major urban areas.

To the north, along the southeastern Alaska coast, the cities of Sitka, Juneau and Valdez are the principal urban centers. For the most part, settlement of this segment of the Coastal sub-biome is far behind that of the lower portion.

3. Taiga Coniferous Forest

Essentially uninhabited outside the Anchorage and Fairbanks urban areas, this vast region of central Alaska has a population density of only 0.5 persons per square mile. Scattered and remote white and native settlements are located along major river valleys and the limited road systems. In percentage terms, Alaska's rate of growth has been rapid in the past decade with a 33 percent increase in population between 1960 and 1970, for a total population of 300,000. Over half of these, 52 percent, live outside urban areas. [86]

Native inhabitants of the sub-biome are of the Na-Dene Indian linguistic stock and are highly dependent on fish and wildlife for their livelihood. [87] Summer employment fighting the numerous Taiga wildfires

is a source of income to the men. Additional employment is available in the numerous small sawmills that operate part time in the Interior to provide logs and lumber for local use. [88]

The lack of adequate road transportation in this area of Alsaka has limited development largely to those areas that are reachable by the few existing roads. Air travel is used extensively throughout the Interior. Consequently, much of the region remains wild, remote and inaccessible and represents one of the largest remaining contiguous wilderness areas in the world.

A primary land use in the Taiga is the harvesting of fish and game by the native people and, more recently, by white settlers and recreationists.

Mining has been the only other appreciable land use in the region -- gold mining early in the century and, more recently, oil and gas exploration and development. Oil on Alaska's North Slope and a proposed pipeline crossing the Taiga would drastically affect land use. The introduction of economic and human activity in the pipeline corridor is covered in depth in the U.S.D.I. Proposed Trans-Alaska Pipeline Final Environmental Impact Statement and other publications. [89]

The remoteness of interior Alaska, the lack of transportation facilities, the extremes in weather, and the sparsity of established communities present monumental obstacles to the development of interior Alaska's timber resources. Most of the better stands of timber occurring in the major river drainages are scattered over great distances and

located in some regions where transportation is currently not feasible. The logistical problems and lack of economical transportation makes Interior timber non-competitive with more desirable species and size available in the coastal region of Alaska. [90]

A most significant land use of the vast Alaskan interior that can be expected to increase sharply in the future is outdoor recreation. Current estimates show 9.8 million acres of natural lakes and reservoirs, 50,000 miles of fishing streams, 255 million acres of big and small game habitat (containing 760,000 big game animals) and 67 million acres of waterfowl habitat located on the public lands, most of which are within the Taiga region. [91] Estimated recreation visits to the public lands within the region during 1971 exceeded 5.8 million. [92] In addition, the streams and lakes yielded an estimated 69.5 million pounds of commercial fish harvested in 1971. [93]

Livestock grazing (cattle, horses, sheep, goats and reindeer) took place on approximately 1.5 million acres of public land during 1970. [94]

Although the majority of the land within the Taiga is presently in public ownership, future jurisdiction will depend on relative resource values and the interaction of the Alaska Statehood Act (State selection of public land) and the Alaska Native Claims Settlement Act (PL 92-203).

Climatic extremes severely limit human habitation and land use. Severe winter temperatures, short summers, and wide occurrence of permafrost dictate a careful evaluation of all intensive future land use that may be proposed. [95]

L. Aesthetics and Human Interest Values

1. Aesthetics

The Montane Coniferous Forest and, to a lesser degree, the Northwest Coastal Coniferous Forest, provide some of the most spectacular scenery in the western United States. Such natural attractions as Yellowstone Park, the Grand Canyon and numerous other lesser known sights located throughout the Montane region annually attract hundreds of thousands of sightseers. Further west the Coastal redwood forests of northern California and the rainforests of the Douglas-fir region of western Oregon and Washington offer a more or less continuous panorama of towering forest broken by occasional streams tumbling from the Coast Range Mountains to the Pacific Ocean. Less apparent from the ground except in localized areas, man's intrusion into the coastal forest with roads, power transmission corridors and timber harvest activities create harsh contrasts when viewed from the air.

Land forms vary from the rounded foothills of the Cascades and Coastal Range to the angular peaks of the Rockies, from relatively flat mesas and basins to nearly vertical canyons. Natural lines occur more often in the environment of the Montane than in either the Coastal or Taiga sub-biomes. These may occur as abrupt changes in vegetation types caused by soil changes, avalanche paths or rock intrusions. They may occur as horizontal deposition lines on the face of an exposed cliff or cut bank.

Scale is frequently so vast as to be overpowering to those more accustomed to urban surroundings. The extreme vertical relief common to the mountains is frightening to some. To others the solitude of the mountains and the remoteness of the Taiga Coniferous Forest offer a welcome contrast. The wide variety of forms, textures, colors and natural lines are what make the scenic values interesting, while vastness of scale and distance bring feelings of isolation and solitude to those who live within or visit this region. [96]

2. Geological Human Interest

The Montane contains geoligically interesting features left by glaciation. Included are morains, lakes, U-shaped valleys; erosion features like canyons, pinnacle peaks and mudlows; volcanic features such as lava flows, eroded ash beds, dikes, exposed plugs, calderas, hot springs and geysers. [97]

The Taiga also shows evidence of glacial action. Such structures as moraines, drumlins, glacial lakes, and other features occur, along with features associated with permafrost and its actions such as pingos, thaw lakes, beaded drainages, etc. [98]

The Northwest Coastal is edged with an interesting eroded coastline of natural arches, isolated rock islands, sand dunes and steep cliffs. The higher elevations contain canyons, volcanic features, caves and faulting evidence. [99]

3. Archeological Human Interest

Early man's entry into the New World from Asia via a Bering Strait land bridge, estimated to be 1000 miles wide when the seas were at their lowest, is believed to have occurred between 20 and 40 thousand years ago. Radio-carbon dated remains going back to about 10,000 B.C. show well-developed stone-chipping techniques and hunting skills adapted to the taking of large animals. Most evidence comes from game kill sites and stratified cave deposits. [100]

The Montane Forest was utilized for food gathering and hunting by the Desert culture that developed in the trans-Rocky Mountain west.

In the Taiga, the Old Bering Sea culture developed into the early stages of Eskimo culture based on the hunting of sea animals. [101] Further inland in the Alaskan interior the sub-Arctic culture, based on the Old Cordilleran and Big Game Hunting traditions, developed into the Northwest Microblade tradition of people who lived by hunting caribou, elk, buffalo and fishing. The Microblade tradition is felt to have provided the core for the Denetasino tradition which became the Athabascan speaking Indians. Archealogical sites are mostly campsites along streams and lakes and on ridgetops with occasional rock shelters.

The Northwest Coastal Coniferous Forest was the home of the Northwest Coast culture. Essentially a river or river-mouth culture, oriented around salmon fishing, the Northwest Coast culture is noteworthy for its vigorous and distinctive art and great use of wood. Village sites were located along streams and near sheltered inlets along the

coast and consisted of both pit and surface houses. Occasional rock shelters and some campsites away from the streams are found. [102]

4. Historical Human Interest

The Montane shares its history with that of the nearby grasslands and desert. Many of the early settlements started as mushrooming mining camps that later blossomed into the present day cities of Baker, Lewiston, Boise and Helena. [103] Most of the early mining camps became empty shells as the ore petered out and their inhabitants moved on to greener pastures. Some of these "ghost towns" such as Montana's Virginia City have survived the ravages of time and today are popular tourist attractions. Other early settlements grew up around military forts and trading posts located along exploration and immigration routes to the West. Today many of these early sites have been given national designation as historical sites and monuments.

The early history of the Northwest Coastal developed around fur trading, lumbering, and to a lesser degree, mining. Spain, England, Russia and the United States all laid claim to this region through discovery, exploration, and occupation. One of the earliest white settlements was Astoria, established as a fur trading post by John Jacob Astor's Pacific Fur Company. This company was later sold to the Hudson's Bay Company which relocated the headquarters a hundred miles up the Columbia from Astoria and established Fort Vancouver, which exists in the present as a national historic site. [104]

Approximately 20 years after the establishment of Fort Vancouver the few American settlers in the Oregon country, tired of living under British laws and the authority of the Hudson's Bay Company, met at Champoeg, near Newberg, and voted to establish a provisional government until Congress would extend jurisdiction over them. This was the first American government to be established west of Iowa. Today Champoeg is a State park. [105]

Scattered throughout the Coastal Forest are remainders of the region's early history. Old mining and logging camps, remnants of military posts, and preserved homes of early pioneers are some examples.

The Taiga of Alaska was initially claimed and explored by Russia. Early trading posts and missions (some still in use) were established during the period of exploration. After purchase by the United States the area experienced a gold rush which created numerous "boom and bust" settlements, of which the relics of many still exist. Many of the present native settlements occupy sites that were established hundreds of years ago. Some remain little changed from primitive times. [106]

5. Cultural, Ethnic and Religious Human Interest

Numerous Indian groups currently make their home in various locations scattered throughout or nearby the Montane Forest. Most of these reside on the following reservations which extend into the Montane Forest; Colville, Yakima, Coeur d'Alene, Nez Perce, Flathead, Warm Springs, Crow and portions of the Navajo, Uintah and Ouray, Pueblo, Fort Apache and Tule River Indian Reservations. Many of these groups derive part of their economic and spiritual sustenance from the Coniferous Forest. [107]

The Taiga Forest of Alaska contains one of the largest remaining native American groups still living in much the same way as they have since contact times. They depend to a large extent upon the Taiga for their livelihood.

The Northwest Coastal Forest contains two small Indian Reservations, the Quinalt and Hoopa Valley Reservations. Both rely to some degree on the Coastal Forest for their livelihood. [108]

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